FINAL REPORT

OF

THE PEAT COMMITTEE

APPOINTED JOINTLY BY THE

GOVERNMENTS OF THE DOMINION OF CANADA AND THE PROVINCE OF ONTARIO

B. F. HAANEL

HONORARY SECRETARY AND MEMBER PEAT COMMITTEE

MINES BRANCH

DEPARTMENT OF MINES

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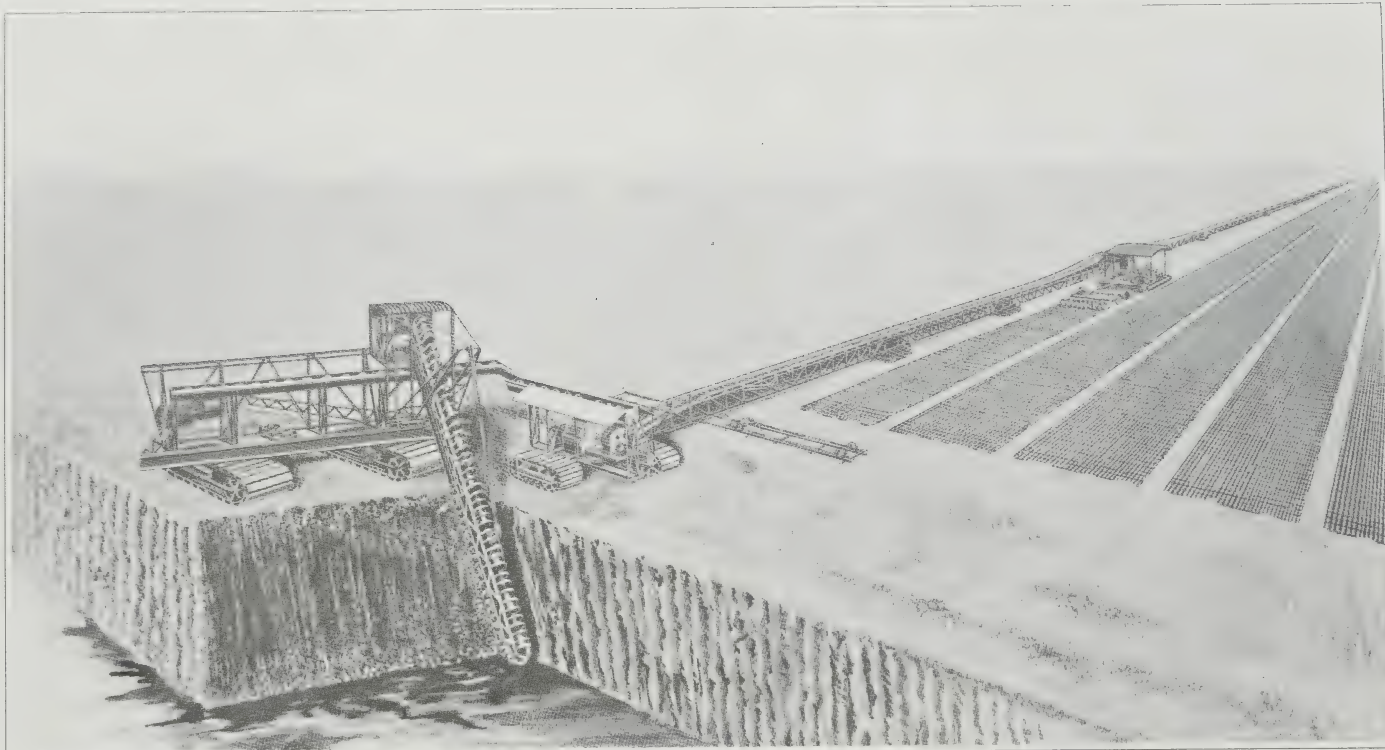

Perfected Plant No. 4 as recommended by the Peat Committee

CANADA
DEPARTMENT OF MINES
HON. CHARLES STEWART, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

MINES BRANCH
JOHN McLEISH, DIRECTOR

FINAL REPORT
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PEAT
Its Manufacture and Uses

BY
B. F. HAANEL
Honorary Secretary and Member Peat Committee

Published jointly by the Mines Branch, Department of Mines, Canada
and the Department of Mines, Ontario

Mines Branch No. 641

Peat Committee

Arthur A. Cole, Mining Engineer, Temiskaming and Northern Ontario Railway Commission	Chairman
Robert A. Ross, Consulting Engineer, Montreal	Member
Roland C. Harris, Commissioner of Works, Toronto	Member
B. F. Haanel, Chief of Fuels and Fuel Testing Division, Mines Branch	Honorary Secretary and Member

FOREWORD.

The accompanying report, which has been prepared under direction of the Peat Committee, contains a presentation of the results of the investigations conducted, and the operations carried on by the Committee in pursuance of instructions received from the Governments of the Dominion of Canada and the province of Ontario, early in 1918.

The objective of the investigations, which were financed by the two Governments jointly, was to find, if possible, a practical working method, capable of commercial operation on a large scale, whereby our extensive peat deposits might be made available as an auxiliary source of fuel supply, especially in the central provinces of Ontario and Quebec, where shortage of domestic supplies of fuel was most keenly felt.

As the result of a careful preliminary survey of methods of manufacturing peat fuel experimented with, or adopted with varying degrees of success, in other countries, the Committee was convinced that the air-dried machine-peat process was the only one that gave reasonable hope of success in attaining this objective, and that, therefore, the development of mechanical appliances to curtail labour requirements and reduce cost of production to the lowest possible limit, was an essential preliminary step towards the establishment of a peat fuel industry in Canada. This opinion has since been strongly confirmed by the findings of the British Fuel Research Board, and the conclusions arrived at by European investigators of prominence.

Part I of the report deals with the character and qualities of peat as a raw material for the production of fuel, and the extent of the peat resources of Canada as defined by investigations which have been carried on for a number of years past by the Dominion Department of Mines. The development of methods of peat fuel manufacture is traced, and the more recent machines employed in the manufacture of air-dried machine-peat in Europe are described and illustrated.

The chapter in this section of the report on the dehydration of peat merits special attention. Numerous and costly failures have resulted from attempts to accomplish the dehydration of peat by what may be termed artificial methods, in contradistinction to the natural air-drying process. A clear understanding of the negative character of the results obtained in such cases, and of the underlying principles involved, should prevent expenditures by investors in fruitless efforts which through their failure might tend to discredit the peat industry in general.

The field operations of the Committee at Alfred, Ont., the machines developed, and the findings and conclusions of the Committee in relation to the several matters involved in the investigation are comprised in Part II; while Part III is devoted to special applications and uses of peat fuel, including a description of the experiments conducted in the carbonization of air-dried peat fuel.

Since the establishment of a peat fuel industry will naturally raise the question of disposal of those areas of the peat bogs not worked for fuel production as well as those from which the fuel peat is in course of time removed, a chapter on agricultural uses of peat and peat lands has been included in this report. Reports of special investigations made are also contained in the appendices.

It will be evident from a perusal of the report that the efforts of the Committee have met with a gratifying measure of success, that the object of its appointment has been substantially attained, and that the prospect of the establishment of a peat fuel industry in Canada on a sound economic basis has been materially advanced. This is of special interest to the northern districts of Ontario and Quebec where wood and peat are the only available local sources of fuel supply, since the wood resources convenient to the populated sections are being rapidly depleted, and the development of known peat deposits of good quality becomes constantly a more attractive proposition, and a matter of increasing concern to the community.

ARTHUR A. COLE,
Chairman, Peat Committee.

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INTRODUCTORY

The serious fuel shortage with which Canada was confronted in 1917 and which threatened to assume alarming proportions, forcibly directed public attention to the isolated position that the central portion of Canada, more especially the provinces of Ontario and Quebec, occupies with respect to sources of fuel supply for domestic and other purposes. The interest aroused by the general realization of the absolute dependence of these provinces on a supply of fuel from foreign sources led to efforts on the part of the Government of Ontario and the Reconstruction and Development Committee of the Federal Parliament to ascertain the feasibility of utilizing for domestic purposes, the large fuel resources lying dormant in the numerous peat bogs strategically distributed throughout the inhabited portions of this area.

Early in 1918 these efforts took tangible form in the appointment of a Joint Peat Committee, financed equally by the Federal Government and the Government of Ontario, and in its personnel representative of the respective governments, to conduct an investigation concerning ways and means for converting the peat content of Canadian bogs into a marketable fuel. Although the feasibility of manufacturing air-dried peat fuel in Canada had been previously demonstrated by operations conducted by the Mines Branch of the Department of Mines in 1910-11, nevertheless, conditions as regards labour and other important cost factors had changed materially in the interval, and no means had been devised or were actually available for production of fuel on an effective scale under the changed conditions. This necessitated, therefore, a fresh investigation having for its main objective the development of automatic machinery for carrying out economically the operations required to be performed in the several stages of the manufacture of peat fuel according to the air-dried machine-peat process, which, it was well known at that time, was the only economic process for manufacturing peat fuel. Prior to the war the manufacture of air-dried machine-peat in European countries was carried on almost altogether with manual labour, which owing to the comparatively low wage rates existing at that time was quite feasible. But the great advance in the cost of labour at the close of the war in all the civilized countries of the world necessitated the elimination of manual labour wherever possible through the introduction of machinery. This applied to European countries as well as to Canada.

On the creation of a Peat Committee and the appointment of its representatives by Orders-in-Council[1] of the governments concerned, (copies of which are appended), the inaugural meeting was held in the offices of Robert A. Ross, Consulting Engineer, Montreal, for the purpose of organizing and formulating plans for carrying out the investigation. At this meeting Messrs. Robert A. Ross, Roland C. Harris, Arthur A. Cole, and B. F. Haanel were present. Mr. E. V. Moore, Consulting Engineer,

[1]Report of the Committee of the Privy Council approved by His Excellency the Governor General on the 24th of April 1918. P.C. 966. Order in Council approved by His Honour the Lieutenant Governor of Ontario dated the 19th day of April, A.D. 1918.

Montreal, was also present by invitation. At this meeting Arthur A. Cole was appointed Chairman, and B. F. Haanel, Honorary Secretary of the Committee. E. V. Moore who had had wide experience in the designing, construction, and operation of peat plants, extending over a period of seven years, was retained by the Committee as engineer in charge of construction of machines and experimental and development work in connexion with the investigation.

Before commencing the investigation proper, the Committee had to obtain a suitable bog upon which to conduct manufacturing operations. This entailed the examination of several locations, including the Holland, Brunner, Luther, Marsh Hill, and Alfred bogs, all in Ontario. The last mentioned was chosen as the site of operation, owing chiefly to the fact that it was already drained and had a drying-area cleared, levelled, and well prepared by previous use, and also had a working-face developed.

Before constructing peat machines the Committee collected all available information concerning various processes which had been devised for converting peat into a marketable fuel.

Many of the methods which have been proposed and tried out on an experimental, and in some instances on a commercial scale, depend upon the elimination of the large amount of moisture contained in the raw peat by artificial drying, pressing in either hydraulic or filter presses, treatment by electric current or other artificial means; none of these have proved economically successful. The air-dried machine-peat process was found to be the only one in successful commercial operation or even giving the slightest promise of success. This process has been employed in Europe, in some form or other, for over a hundred years, and utilizes the heat of the sun for evaporating the large moisture content of the raw peat substance. The Committee, therefore, eliminated all methods or processes which depend on artificial means for the separation of moisture, and concentrated their efforts on the devising of ways and means for carrying out in the most economical manner possible the various stages of the air-dried machine-peat process.

Prior to the appointment of the Committee the Ontario Government had had under consideration the construction of a complete peat plant according to the Anrep system. Machines for pulping, transporting, and spreading the raw peat, according to this system, had been widely used in Europe, and had also been employed in previous operations in Canada. A mechanical excavator designed by the late Aleph Anrep had also been previously built in Canada, and tried out with a fair measure of success. Although several mechanical excavators had in recent years been developed in Europe none of them appeared to offer advantages superior to those of the Anrep machine. The Federal Government was interested in a new type of machine devised by E. V. Moore. Although no plant of this type had been built, various novel mechanical features of the design were regarded as very promising. Since there was difference of opinion as to the respective merits of the two systems, it was decided to install and thoroughly try out an independent plant of each type, in order to ascertain which would be best suited for use on Canadian bogs, or to determine the best features of each with a view to their combination in a single plant.

In accordance with this programme two plants, which are referred to in this report as Plant No. 1 and Plant No. 2, were built in 1918; installed and experimented with in 1919; and given a thorough trial, under, as nearly as possible, regular working conditions, during the season of 1920. At the end of that season the Committee reported to the two Governments that the Anrep excavating element had been found in actual operation to be superior to that of the Moore plant, but that the Moore spreading system had proved to be far the more efficient, and recommended the building of a new plant combining the best features of the two systems. The combined plant was built during the following summer and tried out during the season of 1922. A small plant which could be operated by three or four men was also designed. Such a plant would be specially adapted for use on the smaller bogs or the shallower portions of large bogs, to meet local requirements for fuel. Incidental to the operations considerable quantities of fuel were manufactured and distributed to consumers at numerous points in Ontario and Quebec.

The operations of the Committee were conducted under conditions which were in several important respects extremely unfavourable, and which led not only to disappointing delays but to larger expenditures than had been anticipated. The original installation of the plants first built was greatly delayed owing to the fact that the work had its inception during the war and at a time when the general state of disorganization of industrial plants throughout the country made it impossible to obtain prompt delivery of machines and parts required. Costs of raw materials entering into the construction of the plants and of general equipment required were unusually high, and rates of wages for labour were at their highest level during the earlier stages of the investigation. The Committee was further seriously handicapped by the circumstance that it had only a lease of life from year to year. This occasioned at times lengthy delays, due to waiting for authority to proceed or for necessary funds to carry on the work of the investigation, a difficulty that was further complicated by the difference in the fiscal years covered by the appropriations made by the two Governments. Actual operation of the machines under investigation, and the conducting of experimental work on the field were naturally confined to a period of a few months during each year. As a result of the conditions mentioned, the time at the disposal of the Committee for such work was still further curtailed, and this led to an unforeseen extension of the period of the investigation, the cost of which was in consequence materially increased beyond the original estimates.

Meteorological observations were regularly made during the seasons of 1920-22, and detailed investigations as to the drying of peat on the field were conducted by H. A. Leverin of the Mines Branch, Department of Mines, Ottawa, whose report is included as Appendix A.

Research work was also carried on at the Fuel Testing Station of the Mines Branch, Ottawa, which had as its objective the determination of the effect of varying degrees of pulping on the rate of drying and physical properties of the raw peat, and the density and other characteristics of the fuel produced. See Appendix B.

In order to ascertain whether peat fuel manufactured according to the air-dried machine-peat process could be economically employed as a substitute for hardwood in the wood-distillation plants, full-scale tests were made with peat fuel in the hardwood distillation retorts at one of the plants of the Standard Chemical Company under the supervision of R. E. Gilmore and the late Mr. H. Kohl of the staff of the Division of Fuels and Fuel Testing, Mines Branch.

An exhaustive investigation, still under way, is being conducted in the laboratories of the Fuel Testing Station concerning the briquetting of peat with or without the addition of coals, and with various types of binders. This investigation, however, is not sufficiently advanced to furnish any results.

At the close of the investigation a minute was passed at a meeting of the Committee requesting the Secretary to prepare a final report embodying such general information as might be thought desirable to afford a comprehensive view of the peat industry to date. The writer has endeavoured in this report to compile in a concise manner, accurate information concerning the various methods and processes which have been devised from time to time, not only in Canada but in the United States and other countries, for converting the raw peat of a peat bog into a fuel suitable for domestic and other purposes. Many of the processes briefly described have been thoroughly tried out on a laboratory scale, some on a technical scale, and others have passed through the commercial development stage, and since many of these are based on principles which are incorrect and therefore cannot be carried out economically, only sufficient details are given in describing them to enable the reader to obtain a clear understanding of the principles on which they are based and the reasons for their failure. Certain of the attempts which have been made in Europe to dehydrate peat by submitting it to pressure in a specially constructed press have been dealt with in more detail, inasmuch as at the time of writing certain of these processes are still undergoing the development stage, but like their predecessors, it is the opinion of the writer, they will fail to produce economic results.

The operations carried on in 1919 at Dumfries, Scotland, in manufacturing peat-fuel briquettes by Ekenberg's wet-carbonizing method were specially investigated on behalf of the Swedish Government by J. O. Roos of Hjelmsäter, Director of the Government Testing Laboratories at Stockholm, Sweden. His report thereon has also been translated, and is contained in Appendix C. The short bibliography following this report, although confined chiefly to publications in the English language, and by no means exhaustive, will serve to indicate the more important sources of information available to English readers.

Throughout the report the words maceration, pulping, and pulverizing are synonymously employed to describe the operation of reducing the raw peat to a pulp. This is due to the use of these words in current literature which has been in certain cases quoted freely and therefore necessitated the retention of the words used to indicate this stage in the process. Maceration, the writer contends, is not the correct word to use to describe the change which takes place in peat when submitted to the beating action of the hammer mill shredder, (which type of mill was adopted by the Peat

Committee) nor when passed through machines of the type of the Anrep macerator which has a tendency to pug and mix the peat. Maceration implies the reduction to a soft mass by softening or digestion, steeping almost to a solution, and is a term used in pharmaecology. The action which takes place in the Anrep macerator, is a pulping action and the same applies to the hammer mill shredder when such a mill is used for treating peat. Pulping in the writer's opinion would be the proper term to employ.

Kindly and helpful criticisms and suggestions from Professor Pierce F. Purcell, who visited and spent some time at the Alfred plant at the instance of the British Fuel Research Board, are hereby gratefully acknowledged. Thanks are also due for permission to use a number of illustrations from the report of the British Fuel Research Board on The Production of Air-Dried Peat, numerous references to which are also made in the text of this report.

The Committee wish also to express their appreciation of the assistance rendered by the Standard Chemical Company in permitting distillation tests of peat fuel to be made in their plant at Longford, Ont.

To assist the Secretary in preparing this report, A. J. Forward, B.A., was engaged. As Secretary of the Canadian Peat Society and editor of its Journal, Mr. Forward had been for a number of years past in close touch with matters relating to the peat industry, and especially on account of an intimate knowledge of the work of the Committee gained while in its employ during the last two years of the investigation, has been able to render valuable aid, appreciation of which it is desired to record.

P.C. 966.

Certified Copy of a Report of the Committee of the Privy Council approved by His Excellency the Governor General on the 24th April, 1918

The Committee of the Privy Council have had before them a memorandum, dated 18th April, 1918, from the Minister of Mines, concurring in a report from the Deputy Minister of Mines, relative to the establishment of a peat fuel industry to be undertaken jointly by the Government of Ontario and the Government of Canada.

The Minister accordingly recommends that: Messrs Robert A. Ross, C.E., of Montreal, and B. F. Haanel of the Department of Mines, be appointed as representatives of the Government of Canada, to act with Messrs. Roland C. Harris, Toronto, and Arthur A. Cole, M.E., Cobalt, the representatives of the Government of Ontario, as a committee to have general supervision of the investigation, including the establishment of plants, purchase of machinery, the selection and preparation of a suitable peat bog, and the making of practical tests in the manufacture of peat fuel with a view of relieving the fuel shortage in the Central Provinces of the Dominion.

The Minister further recommends that a sum of $36,000 be allocated by the Department of Mines towards defraying one-half of the cost of this investigation to be borne by the Government of Canada, the other half to be borne by the Government of Ontario, and all accounts of expenditure in this connection to be certified by a representative of each Government.

The Committee submit the same for approval.

(Sgd.) RODOLPHE BOUDREAU,
Clerk of the Privy Council.

The Honourable,
The Minister of Mines.

Certified Copy of an Order in Council approved by His Honour the Lieutenant Governor, dated the 19th day of April, A.D. 1918

The Committee of Council have had under consideration the report of the Honourable the Minister of Lands, Forests and Mines, dated April 9th, 1918, wherein he stated that proposals have been made looking to a joint investigation of the peat fuel question by the Government of Canada and the Government of Ontario, and to the appointment of a committee consisting of two representatives of each Government and a fifth member representing both Governments, such Committee to have general supervision of the investigation, including the establishment of plants, the purchase of apparatus, and the employment of labour for making practical tests in the manufacture of peat fuel, and the incurring of all necessary expenses incidental to such operations.

The Minister recommends that such a Committee be formed and that the following persons be appointed thereon as representatives of the Government of Ontario; Roland C. Harris, Provincial Fuel Controller, Toronto, and Arthur A. Cole, M.E., Cobalt, and that R. A. Ross of Montreal be appointed on the Committee as a representative of this Government as well as of the Government of Canada.

The Minister further recommends that Mr. Cole, who is mining engineer of the Temiskaming and Northern Ontario Railway Commission, be transferred from the service of that Commission to that of the Department of Lands, Forests and Mines, for the purpose of the investigation and so long as it shall last; his salary to be the same as the present; namely Three Thousand six hundred dollars ($3,600) per annum, but to be paid by the Department instead of by the Railway Commission, and that the travelling expenses of the said members of the Peat Committee be paid. Mr. Ross is giving his services without charge, and Mr. Harris will act on the Committee in his capacity as Fuel Controller.

And the Minister further recommends that all the moneys to be paid out in connection with the work of the Peat Committee shall, in the first instance, be disbursed by the Government of Canada, and that one half the expenditure in this Province shall be refunded to that Government by the Government of Ontario out of the Vote of One Hundred Thousand ($100,000) appropriated for investigating the fuel question by Vote 238, Item 11 of the Estimates of 1918-19.

The Committee concur in the recommendations of the Minister and advise that the same be acted on.

Certified,
(Sgd.) J. LONSDALE CAPREOL,
Clerk, Executive Council.

CHAPTER I

PEAT: ITS ORIGIN AND NATURE

Peat is a combustible substance produced by the incomplete decomposition of vegetable matter either in or in the presence of water under such conditions that atmospheric oxygen is excluded. The character of the peat depends upon the conditions under which it has been formed, and on the nature of the vegetation which has contributed to its formation.

Though many species of plants are found in peat bogs, and a very large number have contributed material to form peat, only a comparatively few have supplied the bulk of the contents of the bogs. Prominent among peat-forming plants are: mosses, such as sphagnum and hypnum; marsh plants, such as nymphæa and calla; heath plants, including several varieties of erica and vaccinium; grasses, rushes, sedges, ferns, algæ; marine plants such as phragmites, scirpum, equisetum; and sometimes trunks, roots and leaves of trees, etc.

According as one or another of these plants has predominated in the formation of a bog, the peat contained is described as moss, sphagnum, hypnum, grass, Eriophorum, carex, heather, forest, or marine peat, etc. Sphagnum peat contains a very small amount of incombustible matter and gives, therefore, when burnt, very little ash. When well humified it has fairly good cohesion and produces a good fuel. Hypnum peat has a high ash content, and is suitable for fuel manufacture only when well humified and mixed with the remains of other plants with lower ash content. Bogs in which hypnum peat is the prevailing type are rich in nitrogen, lime, and other nourishment, and are as a rule well adapted for agricultural purposes. Grass peat, particularly that formed from Eriophorum, when well humified gives a black, heavy and compact fuel, with low ash content, and is the best raw material for the manufacture of peat fuel.

Peat bogs are classified as high bogs and low bogs. High bogs are principally composed of the remains of mosses, heath plants and forest residue. Under favourable conditions they may attain considerable depth especially towards the centre, where the drainage is less and the growth of the moss more profuse. The central parts are generally higher than the margins of the bog and are sometimes from 15 to 50 feet in depth. The vegetation on low bogs comprises grasses, sedges, reeds and rushes. Low bogs occur chiefly in localities which are occasionally or periodically flooded. Owing principally to changes of water-level, the conditions under which many bogs have been formed have changed from time to time resulting in different characters of vegetation and qualities of peat, and giving rise to what are known as mixed or transition bogs. High bogs contain generally a smaller admixture of earthy substances, and peat derived from them is usually low in ash and high in carbon content, whereas low bogs contain more earthy matter and are higher in ash.

Conditions necessary to the formation of peat are both climatic and topographical. The principal factors are:—

(1) Growth of aquatic and moisture-loving plants.
(2) A soil or subsoil which will retain water at the surface.
(3) Sufficiently humid atmosphere to prevent too rapid evaporation.
(4) A temperature high enough to allow a profuse growth of vegetation, yet low enough to check too rapid a decay of vegetable matter.

Bogs occur in shallow depressions having usually a clay bottom, or when the water rests on permeable matter like sand, overlying an impermeable subsoil. They are most prevalent in lowland districts, but may occur in mountainous country when drainage is impeded so as to form local accumulations of water, which gradually become filled up with silt, and so become fitted for the vegetation characteristic of peat. Glacial action has been an important factor in the origin and distribution of most of the peat bogs in Canada and the United States. The great ice sheets which covered the country during the glacial epoch left irregular deposits of clay, gravel, and boulders which in many places so blocked the stream valleys as to form lakes, and many depressions were formed by the scouring action of the moving ice. Surface drainage of the country was thus seriously affected at a period so recent that there has not been time for it to become re-established, and so enable the streams to drain the thousands of lakes and ponds, and the hundreds of thousands of acres of marsh and swamp land, in the region covered by the last glaciers. The main climatic requirements are regular and abundant rainfall to supply the necessary water, and high relative humidity of the atmosphere to prevent excessive evaporation. Cool or cold air is much more readily saturated with water vapour than is warm air. For this reason countries with temperate or cold climates have generally more humid atmospheres than warmer countries and are most favourable to peat formation. Consequently the southerly portions of Canada and the northerly portions of the United States contain the most extensive deposits of peat on this continent. The states of the Atlantic coastal regions from Virginia, southward, however, and particularly Florida, have large areas of marsh and swamp including many deposits of good peat owing to the heavy rainfall and high relative humidity.

FORMATION OF PEAT AND PHYSICAL PROPERTIES

Plants during their growth take from the air and soil, carbon, hydrogen and oxygen to form cellulose. Eventually the interior walls of the cells become thickly coated with matter which hinders the free transpiration of oxygen and aqueous vapour, and ultimately brings about the death of the cell. When the plant debris at the end of the season falls upon soil where it is exposed to the action of air, oxidation rapidly takes place, and a great part of the organic matter is resolved into gases and aqueous vapour, the carbon being largely converted into carbon dioxide (CO_2). If, however, the debris falls into water or upon soil saturated with moisture and atmospheric oxygen is excluded, decay proceeds very slowly, and a large proportion of the fixed carbon is retained, hydrogen and oxygen being eliminated as water (H_2O), carbon and oxygen as carbon dioxide, and carbon and hydrogen as methane (CH_4). As decomposition of the cells

and cell walls proceeds the vegetable matter is converted into humic and allied acids and carbonic acid, while the soluble compounds slowly pass away in solution and the resulting mass contains a large and increased proportion of carbon, with small quantities of hydrogen and oxygen in combination. The final stage is the destruction of the fibres and more resistant tissues, thus leading to the formation of peat humus. Peat is exceedingly variable, so that scarcely any two deposits contain material which is exactly similar in all of its physical properties. Even in the same bog peat of distinct types may and frequently does exist. Owing to their different degrees of humification, the upper layers of a bog in many cases differ in many of their properties from those below them. The determination of the prevailing character of the peat contained in a bog, as well as of its extent, is therefore essential before its economic development for production of fuel or other purposes can be intelligently undertaken.

Colour

Peat in the natural state ranges in colour from yellowish brown through various shades of brown to jet black. The lighter shades usually change to dark brown or black after the peat is mechanically treated and exposed to the air. Where peat formation has been intermittent a section of the bog will present a banded appearance. Where it has proceeded regularly, humification of the lower layers being further advanced, the upper layers of the bog will be lighter in colour, shading to dark brown or black in the lower strata. The more complete the humification, and the more thorough the disintegration, the darker is the colour. Peat that is greenish when wet, or that is grey, rusty, or spotted with white when dry, or that is unduly heavy, owes these characteristics to the presence of mineral matter, and is probably unsuitable for fuel.

Texture

The texture and uniformity of peat in a given deposit depend upon: first, the kind of bog, whether high or low; second, the character of the plants which have furnished material for the formation of peat, and third, the completeness of disintegration of their organic structure. True moss peat, even when poorly decomposed, does not furnish fibrous material. Usually, however, bogs contain in greater or less degree, tough fibrous matter derived from cotton grasses, Eriophorum, and other sedges. Well-preserved trunks, stumps and roots of trees and shrubs, are found in large numbers in many peat bogs, and may seriously affect the problem of excavation of the raw peat.

Composition

The solid material found in peat bogs is of both organic and inorganic origin. Each of these groups may be subdivided into two others—soluble and insoluble. The carbonaceous or combustible portion of peat is entirely of vegetable origin. Varying, though usually very small, quantities of the mineral matter of peat are also derived from the plants of which the peat has been formed and the animals associated with them. The mineral matter, other than that of organic origin, is either brought in by the water in suspension or solution or blown in from the surrounding

land. What might be important sources of fuel supply are sometimes rendered unfit for use by the great amount of incombustible material distributed throughout or interspersed between the layers of peat. Stones and pebbles as well as the finer sands, silts and muds may be carried into peat beds, at times of high water, where the deposits are subject to overflow from streams. Dissolved mineral substances brought to peat beds may be chemically precipitated in the peat as insoluble substances, or may be concentrated by the evaporation of the water from the surface of the peat. Iron sulphide is an example of a chemically precipitated substance. Ferrous sulphate and salts of magnesium and calcium which accumulate in peat bogs subject to overflow by spring or pond water, rich in mineral matter or lying above beds of marl, may also be taken as illustrations of concentration due to evaporation. Sand is sometimes blown into the peat by storms.

Water-holding Capacity

Peat has great capacity for taking up and holding water, and can only be formed where vegetation is saturated with or covered by water. Most bogs contain 90 per cent or more moisture, in other words the dry substance holds nine times its own weight of water. A portion of this water may be removed by drainage, but a well-drained bog still has ordinarily a water content of about 87½ per cent, a portion of which is held in the cell walls and intercellular spaces of the organic remains of the plants, while the remainder is combined with the humus particles in colloidal suspension. The very high water-holding capacity of peat is largely due to the fact that the constituent particles of peat humus are exceedingly minute, and present a very large surface area in proportion to their mass, and have, therefore, a strong attraction for the molecules of water, and in the presence of large quantities of water remain in suspension, forming a colloid similar in many respects to gelatine.

Subjection to extreme degrees of either heat or cold tends to destroy the colloidal character of peat. Drying also materially affects its water-holding capacity. Peat humus is an irreversible colloid. Certain colloids are reversible, but peat does not belong to this class. When the water is evaporated from raw peat, its colloidal properties are destroyed, and the resulting dry substance consists of aggregations of associated particles which are no longer capable of absorbing large quantities of water. This property is of very great practical importance in the production of fuel from peat, since, by drying the raw material, a product is obtained which is comparatively very slightly hygroscopic.

In an experiment conducted at the Fuel Testing Station of the Mines Branch, at Ottawa, small air-dried peat briquettes were immersed in water, and the rate of absorption noted as follows:—

	Per cent
Moisture content of air-dried peat briquettes	9·5
" " after being over night in water	26·0
" " " " 6 days in water	37·5
" " " " 29 " "	40·0
" " " " 57 " "	43·0

On allowing the briquettes to air dry the moisture content at the end of a week came back to 9·8 per cent.

Heat Conductivity

Peat has very low thermal conductivity. According to Dr. Fürst, a heap of ice covered with peat was made at the Bockelholm bog in 1888-9 and, without replenishing the store, was taken out in an unthawed condition in the summer of 1891.[1]

Weight, Density, and Specific Gravity

The different types of peat vary considerably in weight for a given unit of volume. The actual specific gravity of plant fibre, and of peat substance derived from it is greater than unity. Ordinarily, however, because of the many open spaces and air-containing cavities in peat, the specific gravity as obtained is generally much less than unity. The figures determined for the dried peat substance range from about 0·1 for very fibrous, poorly decomposed moss peat to 1·06 for compact, thoroughly decomposed black peat. The actual dry weights are, for the lighter and undecomposed fibrous kinds of sedge and moss peats, 7 to 16 pounds per cubic foot; for the brown and more thoroughly disintegrated types from about 15 to 45 pounds per cubic foot; and for dense, black, non-fibrous peat from 40 to 60 pounds per cubic foot of dry matter. The average weight of a cubic metre of raw peat containing 85 to 90 per cent moisture may be assumed as being about 1,000 kilograms.

Densities of Different Types of Peat

Mossy or fibrous peat	0·213—0·263
Young, brown peat	0·240—0·676
Mould peat, mud peat, dough peat	0·410—0·902
Pitch peat, bituminous peat	0·639—1·039

In Oldenberg a dense black peat having a density of 1·3[2] is frequently found.

CHEMICAL COMPOSITION AND CALORIFIC VALUE

Primarily the organic materials from which peat originates are cellulose and lignin, both complicated chemical compounds of carbon, oxygen and hydrogen. Associated with them in plant tissues are considerable quantities of mineral substances. They are also, in many cases, mixed with lesser quantities of other organic compounds such as resins, fatty and waxy bodies, and others which contain nitrogen.

By the decomposition of these substances new and simpler ones are formed. Several substances possessing acid properties have been isolated from peat, such as humic, ulmic, geic, crenic, pectic, and other acids. These with other substances such as humin, ulmin, etc., are often classed together under the comprehensive name of humus.

Bituminous and resinous matters are found under natural conditions in some types of peat, especially in those that are thoroughly decomposed.

[1]Handbook on the Winning and the Utilization of Peat, by A. Hausding.
[2]Op. cit.

The chemical composition of peat varies with the locality of the bog from which it is obtained, and with the plants from which it was formed. Variations in the chemical components of pure peat are, however, comparatively slight, and deviations in composition and behaviour in burning are mainly due to earthy admixtures, i.e., to the percentage of ash and its composition.

Pure, ash-free, dry peat, according to European authorities, may be assumed to have a chemical composition as follows:—

Carbon	57 to 59 per cent
Hydrogen	5 to 6 "
Oxygen	34 to 38 "

Basing their conclusions on detailed study of the chemical properties of more than 500 samples from different parts of the United States, E. K. Soper and C. C. Osbon[1] say that although the exact atomic relations of the principal elements are not known, and probably are not constant, the formula $C_{62}H_{72}O_{24}$ is typical. This gives a composition as follows:—

Carbon	62 per cent
Hydrogen	6 "
Oxygen	32 "

Either of these compositions may be considered typical of Canadian peats. The outstanding feature of the chemical composition of peat is the large content of oxygen, namely, 32 to 38 per cent which contributes very largely to the low heating value of the substance.

Table I shows analyses of peat from various European bogs.

Table II gives average part analyses of absolutely dry peat from a large number of Canadian bogs that have been investigated; also their nitrogen content, and calorific value of the dry peat.

Table III gives the comparative calorific values of peat contained in 83 Canadian bogs.

The few available analyses of the peat from the vast unsurveyed bogs of the northern parts of Ontario and Quebec indicate that large areas contain peat comparable in quality to that of the bogs investigated in the settled parts of the provinces. Three samples from different points in the Abitibi district analysed by A. G. Burrows, Provincial Assayer, Belleville, Ont., gave the following results (calculated on dry sample)[2]:—

	1 Per cent	2 Per cent	3 Per cent
Volatile combustible	64·6	71·7	73·9
Fixed carbon	26·0	23·0	20·0
Ash	9·4	5·3	6·1

Samples from Mortimer, Crawford, and St. John townships in the Mattagami valley, showed the following composition[3]:—

	1 Per cent	2 Per cent	3 Per cent	4 Per cent	5 Per cent
Volatile combustible	70·17	72·71	70·89	70·45	71·50
Fixed carbon	22·61	21·84	22·11	21·87	23·85
Ash	7·22	5·45	7·00	7·68	4·65

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[1] The Occurrence and Uses of Peat in the United States, by E. K. Soper and C. C. Osbon, U.S. Geol. Surv. Bull. No. 728.

[2] Explorations in Abitibi, by James G. McMillan, Ontario Bureau of Mines Report, 1905.

[3] Exploration in Mattagami Valley, by H. L. Kerr, Ontario Bureau of Mines Report, 1906.

TABLE I

Analyses of Peat from Different Countries*

Description	Water absorbed	Carbon	Hydrogen	Oxygen	Nitrogen	Ash	Authority
Peat dried at 212° F.	......	66·55	10·39	18·59	2·76	1·70	Flickenscher, Germany
" "	......	57·03	5·63	29·67	2·09	5·58	Regnault, France
" "	......	58·09	5·93	31·37	......	4·61	" "
" "	......	57·79	6·11	30·77	......	5·33	" "
" "	......	57·16	5·65	33·39	......	3·80	Mulder, Holland
" "	......	59·96	5·52	33·71	......	0·91	" "
" "	......	50·85	4·64	30·25	......	14·25	" "
" "	......	59·00	5·53	19·50	1·50	14·50	Johnston, Scotland
Average peat	21·9	42·7	4·0	27·4	1·6	2·4	Tyvald
Peat dried at 220° F.	......	57·0	5·5	31·0	1·5	5·0	Dr. Machattis
Surface peat, dried at 220° F. Phillipstown, Ireland	......	58·694	6·971	32·883	1·4514	......	Kane and Sullivan
Dense peat, dried at 212° F Phillipstown, Ireland	......	60·476	6·097	32·546	0·8806	......	" "
Light surface peat, dried at 220° F., Wood of Allen, Ireland	......	59·920	6·614	32·207	1·2558	......	" "
Dense peat, dried at 220° F., Wood of Allen, Ireland	......	61·022	5·771	32·400	0·8070	......	" "
Surface peat, dried at 220° F., Twicknevin, Ireland	......	60·102	6·723	31·288	1·8866	......	" "
Light surface peat, dried at 220° F., Shannon, Ireland	......	60·018	5·875	33·152	0·9545	......	" "
Dense peat, dried at 220° F., Shannon, Ireland	......	61·247	5·616	31·446	1·6904	......	" "
Kilbeggan, Westmeath, Ireland	......	61·040	6·670	30·47	......	......	" "
Kilbuha, Clare, Ireland	......	56·630	6·330	34·48	......	......	Kane
Cappoge, Kildare, Ireland	......	51·05	6·850	39·55	......	......	"
Ockta, in Eastern Russia	......	39·084	3·788	51·088	......	......	Waskrescensky
Peat, 4·5 feet from surface, Tuam, Ireland	......	57·207	5·655	8·9493	2·067	......	Ronalds
Peat, 3·5 feet from surface, Tuam, Ireland	......	58·306	5·821	29·669	2·509	......	"
Peat, 2·5 feet from surface, Tuam, Ireland	......	59·552	5·502	28·414	1·715	......	"
Good air-dried peat, Galway, Ireland	24·2	45·3	4·6	24·1	......	1·8	Dr. Cameron
Poor air-dried peat, Galway, Ireland	29·4	42·1	3·1	21·0	......	4·4	" "
Dense peat, Galway, Ireland	29·3	42·0	5·1	17·5	1·7	3·8	" "
Air-dried peat, Devonshire, England	25·56	54·02	5·21	28·17	2·30	9·73	Vaux
Island of Lewis, Scotland	23·20	60·00	6·90	30·00	1·30	1·90	Paul
Bresles, France	2·17	46·80	5·65	41·15	......	6·40	Marsilly
" "	3·14	47·48	7·16	36·03	......	9·00	"
Thesy, "	3·07	50·67	5·76	36·95	1·92	6·70	"
" "	7·20	43·65	5·79	36·66	......	14·00	"
Bourdon, "	5·55	47·96	6·01	39·30	......	7·00	"
Camon, "	5·59	46·11	5·99	35·97	2·63	9·40	"
Riemencourt, France	1·81	12·99	2·22	19·31	......	65·01	"
Vulcaire, "	......	57·03	5·63	29·67	2·09	5·58	Regnault
Lory, "	......	58·09	6·11	30·77	......	4·61	"
Faramont, "	......	57·79	6·11	30·77	......	5·33	"
Friesland, Germany	......	57·16	5·67	33·39	......	3·80	Mulder
" "	......	59·86	5·52	33·71	......	0·91	"
Holland, "	......	50·85	4·65	30·25	......	14·25	"
Ramstein, "	16·70	62·15	6·29	27·30	1·66	2·70	Walz
Steinwenden, "	16·00	57·50	6·90	31·81	1·75	2·04	"
Neidermoor, "	17·00	47·90	0·80	42·80	......	3·50	"
Prussian, "	15·70	50·13	4·20	31·44	......	8·92	Baer
" "	21·70	55·01	5·36	35·24	......	11·17	"

*Peat, Its Use and Manufacture, by P. R. Björling and F. T. Gissing

TABLE I—Concluded

Analyses of Peat from Different Countries*—Concluded

Description	Water absorbed	Carbon	Hydrogen	Oxygen	Nitrogen	Ash	Authority
Havel, Germany............	17·63	56·43	5·32	38·35	......	9·86	Jackel
" "	19·32	53·51	5·90	40·59	......	6·60	"
" "	18·89	53·31	5·31	41·38	......	6·80	"
Linum, "	31·34	59·43	5·26	35·31	......	11·99	"
Hamburg, "	18·83	57·32	5·32	37·56	......	2·31	"
Bremen, "	57·84	57·84	5·85	32·76	0·95	2·60	Breuninger
" "	......	57·03	5·56	34·15	1·67	1·57	"
Schopfloch, "	20·00	53·59	5·60	30·32	2·71	8·10	Nester and Petersen
Sindelfingen "	18·00	45·44	5·28	26·21	1·46	21·60	" "
Irish peat, perfectly dry, average........................	......	59·0	6·0	30·0	1·25	4·0	P. Dawson
Irish peat, including 25 per cent moisture, average......	25·0	44·0	4·5	22·5	1·0	3·0	"
Irish peat, including 30 per cent moisture, average......	30·0	41·2	4·2	21·0	0·8	2·8	"
Switzerland, air-dried, compressed, average............	23·17	40·09	4·53	21·50	2·84	7·87	Goppelsroeder
Peat, air-dried................	21·9	42·7	4·0	27·4	1·6	2·4	Tyvald

*Peat, Its Use and Manufacture, by P. R. Björling and F. T. Gissing

TABLE II

Part Analyses, Nitrogen Content, and Calorific Value of Peat from Investigated Bogs in Canada

Peat Bog	Part Analyses of Absolutely Dry Peat				
	Volatile matter	Fixed carbon	Ash	Nitrogen	Calorific value, B.T.U.
	Per cent	Per cent	Per cent	Per cent	Per lb.
ONTARIO					
Mer Bleu..................................	68·0	25·0	7·0	1·26	9100
Alfred..................................	68·0	27·0	5·0	1·7	8700
Welland..................................	71·0	24·0	5·0	1·4	8700
Newington..................................	67·0	26·0	7·0	1·7	8500
Perth..................................	71·0	25·0	4·0	1·8	9100
Victoria Road..................................	70·0	25·0	5·0	....	8600
Brunner..................................	64·0	25·0	11·0	1·7	8800
Komoka..................................	61·0	21·0	19·0	1·6	7500
Brockville..................................	66·0	22·0	12·0	2·4	8200
Rondeau..................................	61·0	23·0	16·0	2·7	7900
Holland..................................	64·0	26·0	10·0	2·6	8500
Fort Francis..................................	62·0	29·0	9·0	....	8900
Richmond..................................	61·0	28·0	11·0	2·0	8500
Luther..................................	62·0	27·0	11·0	1·6	8400
Amaranth..................................	60·0	27·0	13·0	....	8700
Cargill..................................	52·0	22·0	26·0	....	7400
Westover..................................	56·0	24·0	20·0	2·3	7900
Marsh Hill..................................	61·0	27·0	12·0	2·2	8100
Sunderland..................................	61·0	28·0	11·0	2·0	8300

TABLE II—Continued

Part Analyses, Nitrogen Content, and Calorific Value of Peat from Investigated Bogs in Canada—Continued

Peat Bog	Part Analyses of Absolutely Dry Peat				
	Volatile matter	Fixed carbon	Ash	Nitrogen	Calorific value, B.T.U.
	Per cent	Per cent	Per cent	Per cent	Per lb.
ONTARIO—Concluded					
Manilla	60·0	29·0	11·0	2·1	8100
Stoco	61·0	23·0	16·0	2·3	7800
Moose Creek	60·2	29·4	10·4	....	8460
Westmeath	62·4	30·4	7·6	....	9360
Meath	56·9	22·7	20·4	....	7960
Thedford	55·0	23·0	22·0	....	6530
Nellie Lake	65·0	28·5	6·5	....	8230
Drinkwater	63·0	27·0	10·0	....	7500
Cochrane	65·5	29·0	5·5	....	8020
Brower	64·0	29·0	7·0	....	9240
St. John	62·0	28·5	9·5	....	8610
Maybrooke	61·0	29·5	9·5	....	7530
Beverly	49·0	30·0	21·0	....	7470
Halton	52·5	24·5	23·0	....	6770
Aberfoyle	57·0	24·5	18·5	....	7100
Pelee Point	60·0	26·0	14·0	....	7925
Harrowsmith	62·5	31·0	6·5	....	8160
Arthur	57·7	28·8	13·5	....	7620
William	63·2	25·5	1·3	....	8630
Twin Cities	62·4	29·0	8·6	....	8730
Verona	61·6	23·6	14·8	....	8180
QUEBEC					
Large Tea Field	65·5	29·0	5·5	2·0	9400
Small Tea Field	64·5	29·0	6·5	2·0	9200
Lanoraie	65·0	28·0	7·0	2·0	9000
St. Hyacinthe	63·0	30·0	7·0	2·0	8800
Riviere du Loup	68·0	29·0	3·0	1·0	9200
Leparc	69·0	28·0	3·0	1·0	9000
Riviere Ouelle	68·0	29·0	3·0	1·0	9200
L'Assomption	67·0	29·0	4·0	2·0	9700
St. Isidore	62·0	32·0	6·0	2·0	8900
Holton	59·0	27·0	14·0	2·0	8500
Farnham	66·0	29·0	5·0	1·7	9700
Canrobert	66·0	29·0	5·0	1·6	9500
Napierville	63·0	28·0	9·0	2·0	8700
Girard	61·0	30·0	9·0	1·7	9100
Pont Rouge	67·0	30·0	3·0	1·4	9300
Clair	68·0	29·0	3·0	1·0	8300
St. Joseph	67·0	29·0	4·0	1·0	8400
Isle Verte	64·0	31·0	5·0	0·9	8200
St. Arsene	65·0	31·0	4·0	0·8	8200
St. Anaclet	64·0	31·0	5·0	1·3	8200
St. Luc	63·5	27·5	9·0	2·0	9400
Sagamite	51·2	21·9	26·9	1·8	7580
Breakeyville	67·4	26·8	5·8	1·5	10100
St. Jean	69·7	25·3	5·0	1·6	10300
Ste. Therese	63·7	26·5	9·8	1·5	10100

TABLE II—Concluded

Part Analyses, Nitrogen Content, and Calorific Value of Peat from Investigated Bogs in Canada—Concluded

Peat Bog	Part Analyses of Absolutely Dry Peat				
	Volatile matter	Fixed carbon	Ash	Nitrogen	Calorific value, B.T.U.
	Per cent	Per cent	Per cent	Per cent	Per lb.
NEW BRUNSWICK					
Seeley Cove	59·0	28·0	13·0	....	8840
Hunter	67·0	30·0	3·0	....	9490
Pocolagan	66·0	31·5	2·5	....	9600
Hayman	63·0	32·0	5·0	....	9520
St. Stephen	65·5	31·0	3·5	....	9360
"A"	65·0	32·0	3·0	....	8990
NOVA SCOTIA					
Caribou	65·4	30·4	4·2	1·18	9600
Cherryfield	64·0	30·0	6·0	1·10	9400
Tusket	61·0	29·0	10·0	1·70	9200
Makoke	66·0	29·0	5·0	1·55	9400
Heath	64·3	28·7	7·0	1·55	9400
Port Clyde	66·7	30·0	3·3	1·13	9700
Latour	68·0	28·0	4·0	1·10	9300
Clyde	64·8	30·2	5·0	1·20	9500
PRINCE EDWARD ISLAND					
Black Marsh	65·0	30·0	5·0	0·85	9800
Miscouche	63·0	30·0	7·0	....	9400
Mermaid	67·0	29·0	4·0	....	9800
MANITOBA					
Lac du Bonnet	59·4	25·0	15·6	....	....
Transmission	56·8	24·2	19·0	....	....
Corduroy	56·1	34·8	9·1	....	....
Boggy Creek	65·0	26·7	8·3	....	8730
Mud Lake	69·1	23·2	7·7	....	8760

NOTE.—The foregoing table has been compiled from the published reports of investigations conducted in 1908-9 by Erik Nystrom and A. Anrep and in subsequent years by Mr. Anrep, supplemented by further data based on later surveys made by Mr. Anrep furnished by the Geological Survey Branch of the Department of Mines. A list of published reports of investigations will be found in the bibliography hereto appended.

TABLE III

Comparative Calorific Value of Peat from Eighty-three Canadian Bogs

B.T.U. per lb.	Ontario		Quebec		Maritime Provinces		Manitoba		Totals		Per-cent-ages
	No.	Tons	No.	Tons	No.	Tons	No.	Tons	No.	Tons	
Under 7500...	4	2,175,000	....	....	....	....	....	....	4	2,175,000	1·1
7500-8000......	9	12,414,000	1	481,000	....	....	....	....	10	12,895,000	6·6
8000-8500......	10	47,615,000	5	7,620,000	....	....	....	....	15	55,235,000	28·0
8500-9000......	12	35,444,000	4	16,522,000	2	63,000	2	777,000	20	52,806,000	26·8
9000-9500......	4	14,473,000	9	35,404,000	8	3,743,000	....	....	21	53,620,000	27·2
9500-10000.....	....	....	3	14,578,000	7	4,214,000	....	....	10	18,792,000	9·5
Over 10000....	....	....	3	1,532,000	....	....	....	....	3	1,532,000	0·8
		112,121,000	....	76,137,000	....	8,020,000	....	777,000	....	197,055,000	

From the above table it will be noted that over 80 per cent of the workable peat in the investigated bogs has calorific values ranging between 8,000 and 9,500 B.T.U.

Generally speaking the bogs of Quebec contain peat of higher average fuel value than those of Ontario. Whereas only about 45 per cent of the Ontario peat exceeds 8,500 B.T.U. in calorific value, about 90 per cent of the Quebec peat has a calorific value of 8,500 B.T.U. or over; and whereas none of the Ontario bogs examined are higher in value than 9,500 B.T.U., over 20 per cent of the Quebec bogs contain peat with a calorific value of 9,500 B.T.U. and over.

Comparatively few bogs in the Maritime Provinces have been examined, and these are only of small area, but the calorific value of the peat is without exception high. Large areas of marsh and bog lands examined in Manitoba have been found to be too shallow, and the peat not sufficiently humified to be workable by present methods.

Calorific Value

The calorific value of peat from the various Canadian bogs as shown in the foregoing Tables II and III is determined on the absolutely dry sample. The heating value, however, of the absolutely dry sample is no index as to the effective heating value of the manufactured peat fuel, since the moisture content of the commercial fuel may be anything from a few per cent up to 60 per cent. It is usual, for power purposes, to deliver the peat to the power plant with a moisture content of from 25 to 30 per cent, and all effective heating values are calculated on this moisture content. In all the calculations and the curves plotted from them, the calorific value of the absolutely dry sample of peat has been assumed to be 9,500 B.T.U. per pound.

To determine the effective heating value when the moisture content and the calorific value of the absolutely dry peat are known, the following formula may be used:

$$A = \frac{1}{100} [100\,B - X\,(B + 1120)] \qquad (1)$$

Where A is the calorific value of the wet peat in B.T.U. per pound; B is the calorific value of the absolutely dry peat in B.T.U. per pound; X is the percentage of moisture contained in the peat for which it is desired to determine the calorific value. The total quantity of heat required to raise one pound of water from 62°F to 212°F and evaporate it, is denoted by 1,120 B.T.U.

If it is desired to calculate the calorific value from the ultimate analysis, the following formula (an adaptation of that of Dulong) may be used:

$$Y = C \times 14600 + (H - \tfrac{1}{8} O)\ 62100 - (9\ H + X)\ 1120 \quad (2)$$

C = weight of carbon
H = " hydrogen
O = " oxygen
X = " water

In this formula, the loss due to the water formed by the combination of the hydrogen and oxygen of the fuel is taken into consideration; whereas in formula (1) such loss is not taken into account.

The following ultimate analysis of a sample of peat taken from the Alfred bog will be used as an illustration.

Carbon	56·0	per cent
Hydrogen	5·2	"
Ash	6·0	"
Oxygen, nitrogen and sulphur by difference	32·8	"

The nitrogen and sulphur may be taken as 2 per cent, leaving 30·8 per cent as oxygen. If a moisture content of 25 per cent is assumed, the percentages of carbon, hydrogen, ash, and oxygen will be:

Carbon	42·0	per cent
Hydrogen	3·9	"
Ash	4·5	"
Oxygen	23·1	"

and these values when substituted in formula (2) will give:—

$$Y = 0{\cdot}42 \times 14600 + (0{\cdot}039 - \frac{0{\cdot}231}{8})\ 62100 - (9 \times 0{\cdot}039 + 0{\cdot}25) \times 1120;\ \text{or}$$

$Y = 0{\cdot}42 \times 14600 + 621 - 673 = 6{,}080$ B.T.U. as the effective calorific value of the wet peat.

The calorific value as determined from formula (1) will be:—

$$A = \frac{1}{100}[100 \times 9460 - 25\ (9460 + 1120)] = 6815 \text{ B.T.U.}$$

Here, 9,460 B.T.U. is the actual calorific value of the absolutely dry peat as determined in the bomb calorimeter.

EFFECT OF MOISTURE ON THE CALORIFIC VALUE OF PEAT

The presence of moisture in peat fuel lowers its effective heating value since a portion of the heat of combustion is utilized in evaporating the contained moisture, and the heat of the steam formed passes off with the flue gases unused. It is highly desirable, therefore, that the moisture content, except for certain purposes, be kept as low as possible when consistent with economy.

The following tables show the effect which the quantity of moisture present in the fuel has upon its calorific value. The column showing the quantity of heat required to evaporate the moisture is calculated: first, assuming that the heat required is only that which overcomes the latent heat of the water, or 970·4 B.T.U. per pound; second, the calculation

TABLE IV*

Heat Required to Evaporate Moisture from Peat

Lbs. of moisture per lb. of peat (dry)	Per lb. of wet peat					H–a	H–b
	Per cent moisture	Per cent peat	Heat content of dry peat H	Heat to evaporate the moisture a	Heat to warm, evaporate and superheat b		
9	90	10	950	870	1170	80	−220
7·3	88	12	1140	850	1140	290	0
6	85·7	14·3	1360	830	1110	530	250
5	83·4	16·6	1580	805	1080	775	500
4	80	20	1900	770	1040	1130	860
3	75	25	2375	720	970	1655	1405
2	66·6	33·3	3166	645	870	2521	2296
1½	60	40	3800	580	780	3220	3020
1	50	50	4750	480	650	4270	4100
2/3 or ·66	40	60	5700	380	520	5320	5180
·54	35	65	6170	340	450	5830	5720
3/7 or ·43	30	70	6650	290	390	6370	6260
1/3 or ·33	25	75	7125	240	330	7885	6795
0	0	100	9500	....	....	9500	9500

*Table prepared by John Blizard.

TABLE V*

Effect of Moisture on Calorific Value of Peat

Per cent moisture in peat	Lbs. of moisture per lb. of dry peat	Lbs. of moisture removed from 1 lb. of peat containing 90% moisture	Per cent of total moisture removed from 90% wet peat	Theoretical lbs. of dry peat to evaporate and superheat the moisture content of 1 lb. peat for 7·3 lbs. water	Per cent of dry peat present available for external use	Net calorific power of 1 lb. of wet peat B.T.U.
90	9·0	·0	0	1·23	0	−220
88	7·3	·17	19·0	1·0	0	0
86	6·1	·29	32·2	·835	16·5	220
84	5·25	·37	41·7	·719	28·1	427
82	4·55	·44	49·5	·622	37·8	646
80	4·0	·5	55·5	·548	45·2	858
77	3·35	·56	62·8	·459	54·1	1182
75	3·0	·6	66·7	·410	59·0	1405
70	2·3	·67	74·2	·315	68·5	1950
66	1·9	·71	78·5	·260	74·0	2390
60	1·5	·75	83·4	·205	79·5	3020
55	1·2	·78	86·6	·165	83·5	3570
50	1·0	·80	89·0	·137	86·3	4100
45	·82	·82	91·0	·112	88·8	4630
40	·67	·83	92·5	·096	90·4	5180
35	·54	·846	94·0	·074	92·6	5720
30	·43	·857	95·2	·059	94·1	6260
25	·33	·867	96·3	·045	95·5	6795
20	·25	·875	97·2	·034	96·6	7240
16	·19	·881	97·8	·026	97·4	7780
10	·10	·890	98·9	·013	98·7	8430

*Table prepared by John Blizard.

assumes conditions that prevail in a gas producer or steam boiler in which it is assumed that the water enters at the temperature of the charged peat—about 60°F—and leaves at the temperature of the hot gases—about 600°F. Under these latter conditions, the total heat required to evaporate the water and then superheat it to 600°F will be, per pound, as follows:—

	B.T.U.
To raise the temperature of the water from 60° to 212°F, 212–60....	152·0
Latent heat of water per pound..............................	970·4
Heat required to superheat the steam, assuming the specific heat of superheated steam to be 0·48, is 0·48 × (600–212)...........	186·0
Total heat per pound of water....................	1,308·4

or, in round numbers, 1,300 B.T.U. per pound.

The calorific value of 1 pound of absolutely dry peat is taken as 9,500 B.T.U.

The curves shown in Figure 1 show graphically the results set forth in the above tables.

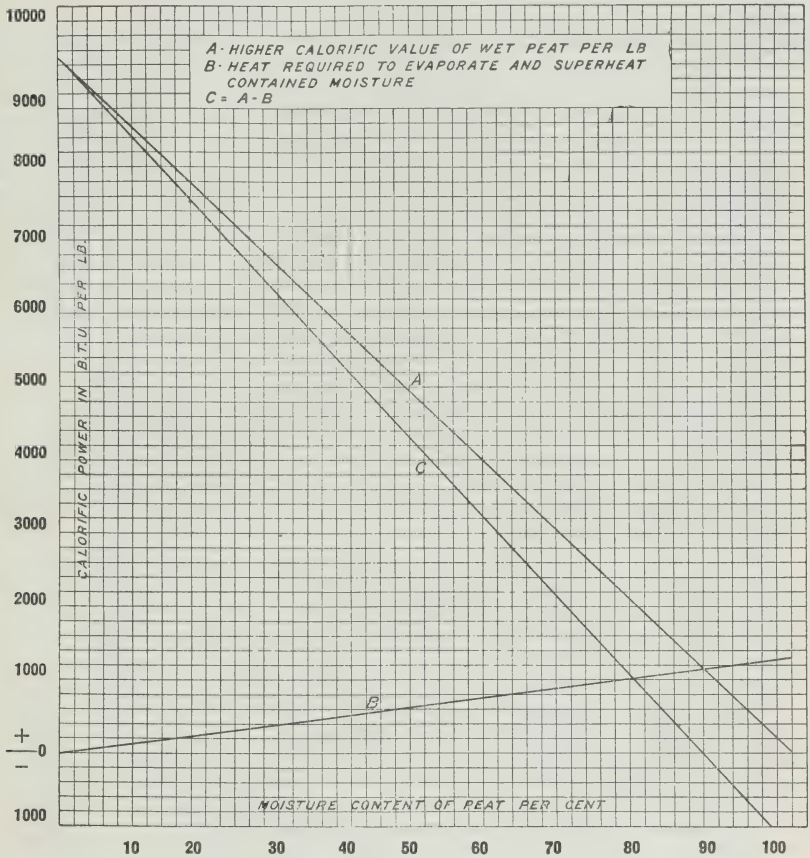


FIGURE 1*—Curves showing the higher and lower calorific value per pound of peat containing different percentages of moisture, and the quantity of heat required to evaporate and superheat the moisture removed.

In these curves A is the higher calorific value of wet peat per pound. B is the quantity of heat required to evaporate and superheat the contained moisture. C is the net or effective calorific value of the wet peat, and is obtained by subtracting the values represented by curve B from those of curve A. The abscissa represents the percentage of moisture in the wet peat and the ordinate the corresponding calorific value in B.T.U. The curves A, B, and C, Figure 2, show the pounds of moisture contained in the peat substance per pound of dry peat for varying percentages of moisture,

*Curves constructed by John Blizard.

the percentage of dry peat available for power purposes in the wet peat, and the percentage of the total moisture contained in the wet peat substance which is removed when the moisture content of the dried peat varies from 0 to 90 per cent.

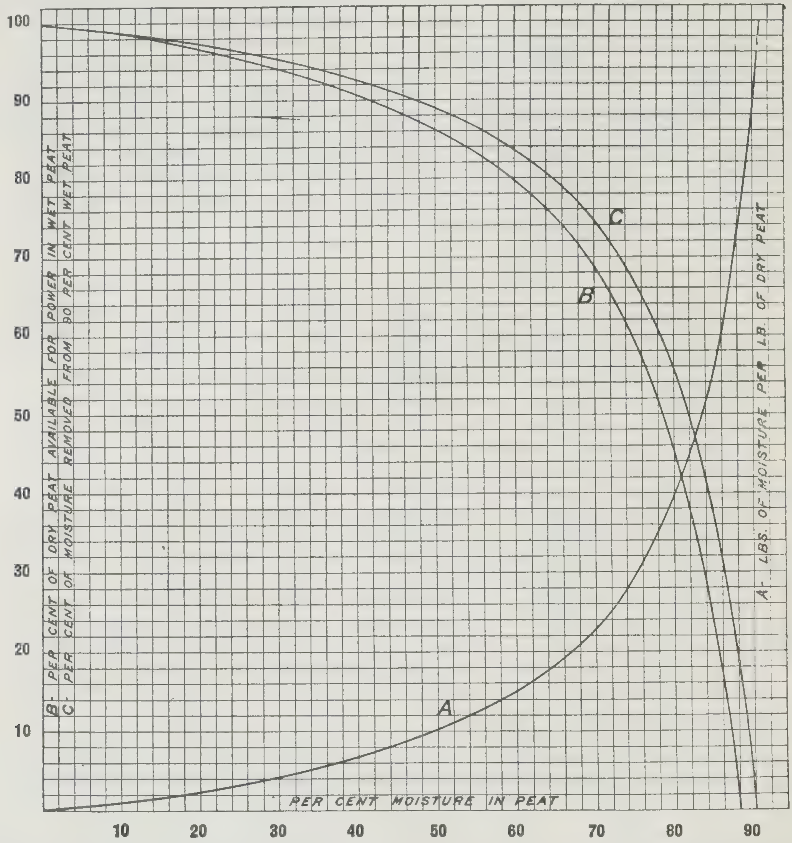


FIGURE 2*—Curves showing pounds of moisture per pound of dry peat, for peat containing different percentages of moisture; percentage of dry peat available for power at different moisture contents, and percentage of total moisture removed from 90 per cent moisture peat in order to obtain peat with different moisture contents.

As an example, suppose it is required to find from curve A how many pounds of moisture per pound of absolutely dry peat are contained in a mass of wet peat containing 50 per cent moisture. The abscissa shows the quantity of moisture in the peat and the right hand ordinate the weight of water in pounds per pound of dry peat substance. Thus 50 per cent on the abscissa will give one pound on the right hand ordinate as the weight of water contained in the 50 per cent wet peat per pound of dry peat, 80 per cent moisture corresponds to 4 pounds of water to 1 pound of dry peat, and 90 per cent moisture to 9 pounds of water per pound of dry peat.

*Curves constructed by John Blizard.

If the peat contains 87 per cent water, by referring to curve B, it will be seen that no dry peat is available for power purposes. The percentage of moisture contained in the peat is shown on the abscissa, as in the previous case, and the percentage of dry peat available is shown on the left hand ordinate. If the peat contains 80 per cent moisture the dry peat available for power purposes is about 44 per cent; for 60 per cent moisture about 79·5 per cent of the dry peat is available; if it contains 40 per cent, over 90 per cent of the dry peat is available, and so on for any per cent of moisture. Curve C is self-explanatory, the abscissa represents the percentage of moisture contained in the peat and the left hand ordinate the percentage of the total moisture content removed from peat with 90 per cent water content, when the moisture content of the dried peat is between 0 and 90 per cent.

Thus to reduce the moisture content of the peat to 50 per cent, 89 per cent of the total water contained in the 90 per cent wet peat substance must be removed, and so on for other moisture contents.

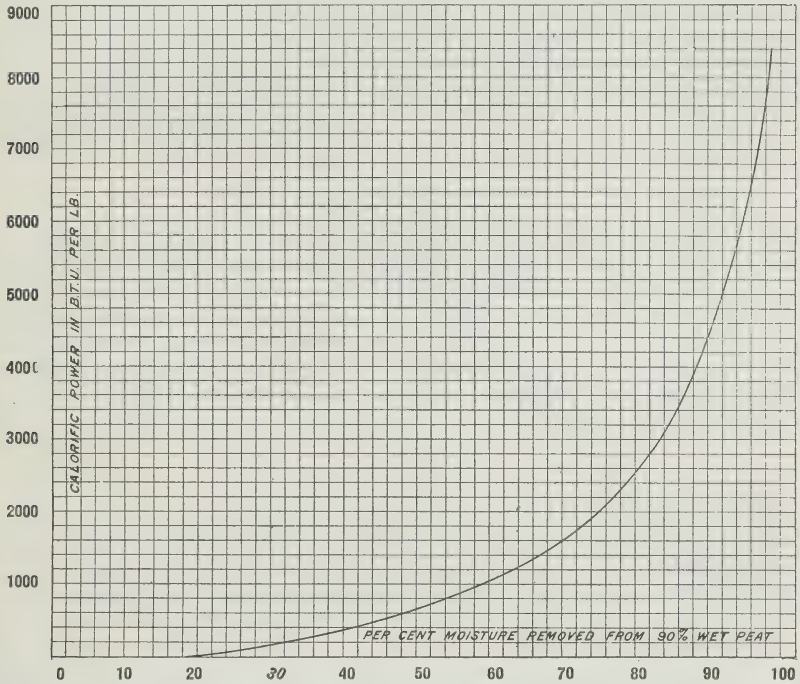


FIGURE 3*—Curve showing the effect on the calorific value of wet peat by removing different percentages of the total moisture content

The effect produced on the calorific value of wet peat by the removal of different percentages of the total moisture is graphically shown in Figure 3. The raw peat is assumed to have a moisture content of 90 per

*Curve constructed by John Blizard.

cent. If now 50 per cent of the total moisture content be removed the calorific value of the peat will be a little over 600 B.T.U. per pound. If 80 per cent be removed the calorific value will be increased to about 2,500 B.T.U.

Nitrogen Content

The peat in Canadian bogs so far examined has, as a general rule, a high content of free nitrogen, 1 to 2·8 per cent.

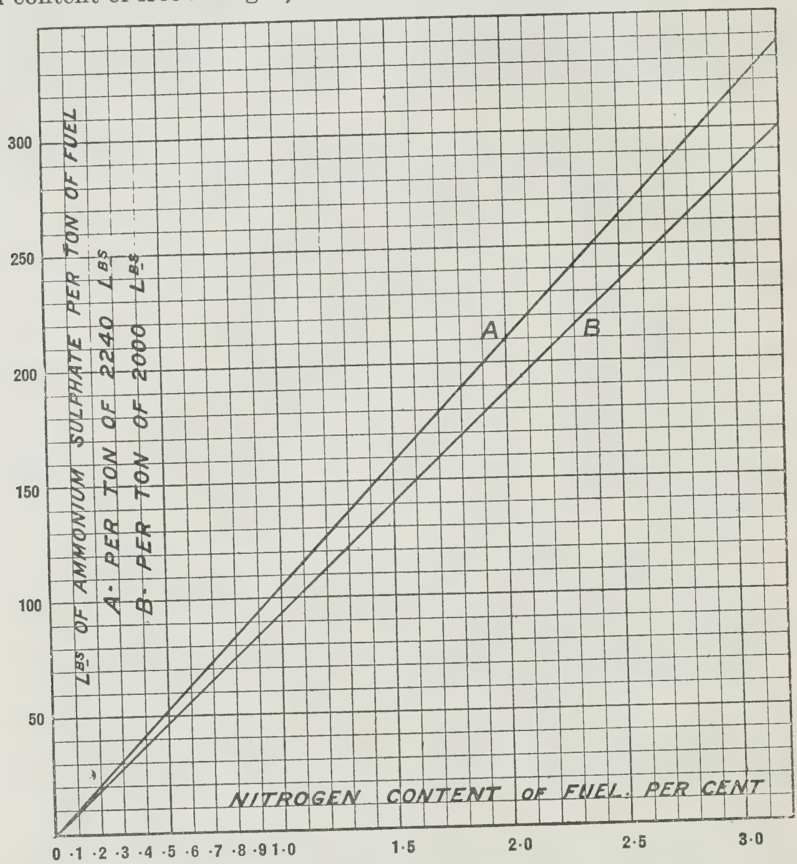


FIGURE 4*—Ammonium sulphate which can be theoretically obtained from fuels having a nitrogen content, varying from 0·1 to 3·0 per cent

The nitrogen content of peat is of importance only when its recovery is contemplated in conjunction with the generation of power gas in by-product recovery gas producers, whereby over 70 per cent of the nitrogen of the fuel may be recovered as ammonia, and utilized in the production of ammonium sulphate, a valuable fertilizing agent.

*Curves constructed by John Blizard.

Ammonium sulphate is a chemical compound composed of the elements, nitrogen, hydrogen, sulphur, and oxygen. It has the molecular formula $(NH_4)_2SO_4$ and contains 25·75 per cent ammonia (NH_3) when chemically pure. The sulphate obtained in commerce, however, may not contain more than 21 to 22 per cent.

From the molecular formula $(NH_4)_2SO_4$ the ratio of the pounds of ammonium sulphate to the pounds of nitrogen is found to be:—

$$\frac{\text{lbs. of sulphate}}{\text{lbs. of nitrogen}} = \frac{132}{28} = 4{\cdot}7;$$

that is, the quantity of ammonium sulphate formed is 4·7 times the quantity of nitrogen entering into the combination. Thus, if a long ton (2,240 pounds) of coal contains 1 per cent nitrogen or 22·4 pounds, the quantity of ammonium sulphate which could be theoretically formed would be $22{\cdot}4 \times 4{\cdot}7 = 105{\cdot}3$ pounds—and for the short ton (2,000 pounds) $20 \times 4{\cdot}7 = 94{\cdot}0$ pounds. The efficiency of the recovery process is seldom greater than 70 to 75 per cent. The ammonium sulphate resulting would, therefore, be: $105{\cdot}3 \times 0{\cdot}75 = 79$ pounds and $94{\cdot}0 \times 0{\cdot}75 = 71$ pounds respectively. Figure 4 shows the quantity of ammonium sulphate which can be theoretically obtained from fuels having a nitrogen content varying from 0·1 to 3·0 per cent nitrogen.

Sulphur and Phosphorus

The sulphur and phosphorus contents of peat are generally very low, almost negligible. For this reason peat coke is a most desirable metallurgical fuel. Where peat is fired under boilers the metal surfaces exposed to the flame are not attacked as when coal is used, and renewals of grate bars are less frequently required.

Determinations made at the Bremen Bog Experimental Station of percentages of sulphur and phosphorus contained in various European peats derived from both high and low bogs gave the following results.[1]

TABLE VI

Percentages of Sulphur and Phosphorus in European Peats, (Dry)

Variety of Peat	Source	Sulphuric acid	Phosphoric acid
Recent sphagnum peat	Nusse	0·57	0·05
Intermediate peat	"	0·43	0·04
" "	Worpedorf	0·35	0·05
Old sphagnum peat	"	0·38	0·03
" " "	Nusse	0·40	0·05
Transition moss and sedge peat	"	0·37	0·06
Transition forest peat	"	0·81	0·05
Marsh forest peat	Ocholt	1·20	0·08
Reed peat	Pippinsburg	1·06	0·09
Mud peat, containing earthy matter	Ocholt	0·72	0·37
Mud peat without admixtures	Dieven Bog	....	0·08
Liver peat	Nusse	1·52	0·11
Heather peat	Pippinsburg	0·18	0·09

[1] Handbook on the Winning and the Utilization of Peat, by A. Hausding,

The average sulphur content of Wisconsin peat and muck, based on a large number of analyses is stated by Soper and Osbon to be 0·6 per cent[1]. Analysis of peat from the bog at Alfred, Ontario, on which operations were conducted by the Peat Committee gave: sulphur 0·218 per cent, phosphorus 0·03 per cent.

Peat Ash

Both the amount and character of the ash content of peat differ very widely in various deposits. When the amount of the ash is less than 5 per cent the peat is said to be low in ash; when between 5 and 10 per cent, it is said to be of medium ash content; and when the percentage exceeds 10, it is said to be high in ash. Though the ash is inert, it displaces an equal amount of combustible matter, and absorbs heat to raise its temperature to and maintain it at the same degree as the accompanying carbon in combustion. High ash content may, therefore, in some instances prove the deciding factor in prohibiting the economic utilization of a given peat bog for fuel production.

Determination of the individual constituents of peat and peat ash may be of considerable importance where peat fuel is to be used for carrying out industrial processes which are affected by the composition of combustion gases, or in which the substances treated come in direct contact with the fuel or ash.

Analyses of Peat Ash from the Alfred Bog:

Silica	18·7
Alumina	9·6
Ferric oxide	7·6
Lime	31·6
Magnesia	14·6
Potash	0·8
Soda	4·7
Sulphuric acid	3·9
Phosphoric acid	1·3
Carbonic acid	7·2
	100·0

The composition of the ash in samples of peat derived from various sources is shown in Tables VII and VIII.

TABLE VII

Analyses of Ash from New England Peat[2]

Inorganic Impurities	—	—	—
Sand	12·11	15·04	67·01
Carbonic acid	19·60	22·28	
Soluble silica	8·23	1·40	....
Iron and aluminium oxide	5·17	9·08	15·59
Magnesia	6·06	4·20	1·05
Lime	41·39	35·59	6·60
Soda	0·58	0·00	Trace
Potash	0·69	0·80	3·46
Sulphuric acid	5·52	10·41	4·04
Chlorine	0·15	0·43	0·70
Phosphoric acid	0·50	0·77	1·55
	100·00	100·00	100·00

[1] The Occurrence and Uses of Peat in the United States, by E. K. Soper and C. C. Osbon, U.S. Geol. Surv. Bull. No. 728.
[2] Op cit.

TABLE VIII

Composition of Various Specimens of Peat Ash[1]

Constituents	Ashes from Bavarian peats, according to Zoller				Ash from Upper Austrian peat according to Ferstl.	Ash from Dutch peat	Ash from Scotch peat, according to Anderson		Ash from American peat, according to Johnson		Bürmoos peat ash, according to G. Thenius			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Potash	1·920	1·04	1·41	1·16	1·56	1·49	0·74	0·46	0·69	0·80	....	....	....	....
Soda	0·954	0·22	0·76	0·59	0·65	1·17	0·99	....	0·58	....	....	....	....	....
Magnesia	2·660	0·90	0·86	0·44	1·37	4·57	0·40	....	6·06	4·92	1·54	1·63	1·55	1·45
Lime	31·470	10·45	6·72	3·22	15·32	11·75	1·18	1·31	40·52	35·59	28·52	29·12	30·05	29·52
Calcium sulphate	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Iron oxide	....	....	....	....	8·76	5·33	c 30·72	12·54	....	....	13·93	14·15	14·23	14·59
Alumina	13·250	21·23	14·84	5·80	14·73	2·98	....	1·85	5·17	9·08	5·46	4·95	5·20	5·15
"Phosphoric acid"	0·960	2·07	0·73	0·48	1·07	Traces	....	Traces	0·50	0·77	0·12	0·13	0·14	0·13
"Sulphuric acid"	2·058	1·14	1·87	0·85	2·59	9·77	5·52	2·02	5·52	10·41	1·53	1·60	1·59	1·45
"Silicic acid"	7·910	21·18	14·45	11·96	....	9·86	....	81·61	8·23	1·40	36·92	37·50	36·29	36·52
Sodium chloride	a 0·568	a 0·37	a 0·48	a 0·35	45·56	1·50	....	0·13	a 0·15	a 0·43	....	....	....	....
Sand, alluvium ("carbonic acid")	38·242	39·30	57·00	74·56	b 10·08	51·57	60·62	....	31·71	37·32	b 11·25	b 10·12	b 10·10	b 10·50
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	99·92	99·13	100·72	99·27	99·20	99·15	99·31
Ash in 100 parts of dried peat	7·60	12·80	....	....	....	....	....	....	....	....	1·12	1·13	1·23	1·12

a Chlorine b Carbonic acid c With ferrous oxide

[1] Handbook on the Winning and the Utilization of Peat, by A. Hausding, p. 15.

CHAPTER II

DEVELOPMENT OF THE PEAT INDUSTRY IN EUROPE

PROCESSES EMPLOYED FOR MANUFACTURE OF PEAT FUEL

Peat has been used as a fuel in Europe for centuries. In its oldest form the process of manufacture of peat fuel consisted of:—

(1) Draining the bog.

(2) Clearing and levelling the surface and stripping the covering moss from the peat.

(3) Cutting the peat in pieces of suitable size with a spade or similar implement.

(4) Spreading these pieces out to dry in the open air.

(5) Turning or placing the "sods" or "turf" in loose piles to promote drying.

The product is known as turf, sod peat, or cut peat. This very simple process, owing to the fact that very cheap and simple tools only are needed, and that it can be carried out on a small scale by one or two men to provide a home fuel supply, has been very widely used. Millions of tons are still produced annually by this method, especially in Ireland where it is estimated that two-thirds of the farming population depend for their fuel supply on peat alone. Peat fuel made by this method is, generally speaking, light, bulky, and porous, readily re-absorbs moisture after drying, and has inferior burning qualities. The continuance of its use in Ireland is largely due to the fact that Irish peats as a rule are well humified, and of comparatively high calorific value, and therefore yield the best possible results obtainable by this process.

Due to the generally lower heating value of European peat deposits, efforts were made to discover means for improving the quality of the fuel produced. These led to the discovery that by kneading and mixing the raw peat with water to form a pulp and afterwards shaping this into blocks, a fuel could be made which was firmer, denser, and superior in quality to cut peat. This process which was developed in Holland and Hanover is known as the Dutch or Hanoverian method, and produces what may be described as "moulded peat." The development in the peat fuel industry of Europe which has taken place within the last seventy-five years has been for the most part merely an elaboration of this method through the introduction of machinery to replace hand labour in carrying on the various operations.

Concurrently with the development of this, which may be termed the "natural method," numerous attempts have been made from time to time to hasten the process, to increase the output, to lengthen the season of operation or to improve the product. In order to attain these objectives recourse has been had to various schemes for:—

(1) Removal of water from the raw peat by pressure, centrifugal force, suction, etc.
(2) Expediting removal of water by electrical treatment, addition of various substances, subjecting the raw peat to steam under pressure, etc.
(3) Artificial drying.
(4) Briquetting.
(5) Carbonization, etc.

All of these schemes involved the use of heat and pressure and have resulted in failure and loss of very large sums of money, and only in a few cases, under special and exceptional conditions, has anything approaching commercial success been achieved.

Cut Peat

Hand-cut Sods or Turfs

For hand-cutting of peat a drained bog is required. A suitable space adjacent to the excavation must also be levelled and prepared for spreading the sods or turfs to be air-dried. The implements used are specially shaped spades for cutting and forks for lifting the sods, and barrows or other means for carrying them to the drying-area. The method of cutting may be either vertical or horizontal, of which the former is the more widely used.

In vertical cutting the workman stands on the surface to be cut and with a spade (slane) cuts the sods of the required size, and lays them on the surface of the bog, to be removed by an assistant who spreads them for drying.

In horizontal cutting a section of the bank, the width of a sod, is first cut vertically. The workman standing in the trench then cuts the pieces horizontally using a special spade called a "lifter."

Other methods of cutting vary only in matters of detail such as shape and size of the sods and form of the implements used.[1]

Hand-cutting of peat is resorted to, especially by country people digging their own fuel supply. Where labour is cheap and plentiful, larger scale production has been sometimes carried on by this method. In such cases the bog was divided into squares of suitable size, each of which was worked by two men. The labour was usually contracted for by the "days work" which corresponds to a fixed volume of excavation in the bank producing a certain number of sods. A skilful workman is able to cut in 12 hours from 6,000 to 8,000 sods, equivalent to the excavation of 24 to 32 cubic metres of peat, which another workman can in the same time spread on the drying-ground.

Methods Employed to Ensure Drying

According to the most general practice, the partly dried sods are turned or footed and, later on, placed in small loose piles for further drying. In Bavaria, a common method was to drive stakes 9 to 10 feet in length in rows on the drying-ground and pile the sods about them, whereas in Finland the sods were speared on sharp pointed stakes holding 8 to 12 sods. A method employed in Carinthia was to spear the sods on pointed cross-arms projecting from poles set in the bog, each pole thus holding about 100 sods. Trestles of various forms, including the "peat horses" of Sweden, were also used to keep the sods from the surface of the bog. In some cases roofed huts or drying-sheds were employed.

[1] Fuel Research Board "The Winning, Preparation and Use of Peat in Ireland, 1921." (Appendix 1).

Machine-cut Peat

In 1842 a hand-operated machine to cut peat sods, and take the place of hand-cutting was built by Brosowski. With this machine 4 men, in 12 hours, could cut and lay 10,000 to 12,000 sods, representing an excavation of 50 to 60 cubic metres of raw peat.

From time to time various small machines were devised for the same purpose, among the more recent being those of Dreyer, Luhrs, Beckmann, Treude, Gross, and others. All these machines could be used also for excavating raw peat to be formed in moulding machines. As their use has been superseded in large-scale production by more efficient power-operated excavators, no detailed descriptions are given here.

Defects of Cut Peat

(1) Subject to deterioration by bad weather during manufacture leading to loss of product and of wages paid for winning.
(2) Re-absorbs water during every shower of rain and must lie for months in the open before it can be brought into sheds.
(3) A great loss of material and labour due to the upper layers of the bog not being suitable to produce cut peat, owing to its fibrous nature, and to destruction of its cohesive properties by the action of heat and cold. Eighteen inches or more of the surface material must be removed and thrown aside as useless.
(4) Sods which break up while being cut are lost.
(5) Owing to the bulkiness of the product its transportation is inconvenient and expensive, and it requires more room for storage than other denser fuels.
(6) On account of its friability there is a great deal of breakage in handling, both during manufacture and in transportation. The average loss due to this cause in the case of light cut peat may run as high as 25 per cent.
(7) Owing to its loose texture it burns away rapidly with only small heat production from a given quantity.

Moulded Peat

The production of moulded peat involves the following operations:—

(1) Digging or cutting the raw peat.
(2) Mixing or kneading.
(3) Moulding or forming into blocks.
(4) Spreading.

In the earlier stages of the industry the digging or cutting was done by hand, as in the production of cut peat, the only variation being that regular shaped blocks were not required. The dug peat was worked in pits by tramping with the bare feet, mixing with shovels, beating with planks, or stamping by oxen or horses. Water was added when necessary to produce a pulp of the proper consistency. The pulp thus obtained was shovelled into moulds laid on the drying-ground and the surface levelled with shovels or hand-scrapers. The moulds were then lifted, moved and refilled as a continuous operation. In this manner operations (3) and (4) were combined.

Mixers of the Pug-mill Type

About 1845 Hasselgren in Sweden made the first notable improvement in the process by utilizing a small vertical pug-mill with knives attached to a slowly revolving shaft to effect mixing and kneading of the raw peat. Shortly after 1850, Hebert operating at Rheims, and in 1858, von Weber at Staltach in Germany, built mixers of this type to pulp the raw peat, the moulding being still done by hand. Two years later Gysser, in conjunction with von Weber, devised a forming mouthpiece attached to the mixer thus combining operations (2) and (3) in one machine. Schlickeysen, Dolberg and others modified and improved the machines. Although the smaller mills were operated by horse-power, larger ones were also constructed for use with steam-power, and their introduction led to a considerable extension of the manufacture of moulded peat or condensed machine-peat, especially in the north of Germany. Machines worked by horses produced from 500 to 1,000 sods an hour with one or two horses. Steam-driven vertical machines of 3 to 10 h.p. made 10,000 to 50,000 sods, or 15 to 75 cubic metres of moulded peat in a day. These mixers of the vertical type, owing to the slow rotation of the knives, produced only a slight mixing effect. Moreover the slowly running, thick knives were unable to exert a sufficient cutting or tearing action on the roots and fibres which are contained in large quantities in many peat bogs. Consequently for their successful operation only those bogs composed of well-humified peat, free from roots and fibres, could be employed, and the use of these machines was on that account restricted.

As the quality of the product depends almost entirely on the thoroughness with which the mixing or pulping operation is conducted it was sought to improve the operation of the machines by the introduction of gearing to increase the revolutions of the knives.

Concurrently with the development along this line, there was also developed a horizontal type of mixer consisting of a cylinder containing a screw which took the peat from the hopper at one end and forced it out through a forming mouthpiece at the other end, its operation being similar to that of the ordinary sausage mill.

The earlier machines of the horizontal type had some disadvantages as compared with the vertical machines. In the latter both the weight of the peat in the hopper and the pressure exerted by the curved knives forced the peat directly towards the exit. In the former the screw moving the peat at right angles to the hopper, through its inability to grip the peat when slippery or when containing lumps or roots, failed to feed the peat in sufficient quantity. To overcome this, Schlickeysen introduced feeding rollers in the bottom of the hopper. Clayton's machine introduced a vertical shaft with revolving knives in the hopper, thus virtually combining the two types. Later this difficulty was overcome by a special construction of the feeding hopper. A more serious difficulty was occasioned by the great diversity of the nature of the peat in different bogs. The arrangement of the moving parts of the machine, adapted for dealing with well-humified peat, was altogether unsuited for handling fibrous peat full of roots. Leo Seydl of Berlin, about 1870, undertook to overcome this by designing a series of machines, each of which was specially adapted

for a certain class of peat; some machines of the series having a greater cutting and tearing action to enable them to dispose of fibrous peat and peat containing roots, and others having only the mixing action required for treatment of clean, well-humified peat.

Various machines followed, differing mainly only in the arrangement of spirals and knives on the shaft. A varying number of knives were provided to produce a cutting and tearing action on the peat according to the more or less fibrous character of the peat to be handled. But these machines met with very limited success as the character of peat varies greatly even in the same bog, and it is therefore not practical to provide a special machine for every special class of peat.

A serious defect of all such machines was the tendency of the peat when in them to rotate with the shaft, reducing to a minimum the mixing effect, and clogging the parts of the machine with roots and fibres. To overcome this, L. Lucht designed a mixer with a single shaft rotating in a cylinder of larger diameter at the feeding end. In this wider part the shaft was supplied with knives rotating against fixed knives placed in the walls, and with a discontinuous screw for moving the peat along in the narrower part of the cylinder. The shaft was provided with a continuous spiral, in which a spur wheel rotated to clean the blades of the screw and promote the mixing of the peat. No special advantages were gained by this construction.

Better results were obtained by the use of machines with parallel shafts, provided with right and left hand intermeshing spirals or blades, revolving in opposite directions. Machines of this class, manufactured by R. Dolberg, A. Heinen, Dr. Wielandt, W. K. Strenge, Karl Schenck, Arthur Koppel, and others, are now in general use in Europe.

A. Anrep's older machines which are still extensively used, especially in Russia, had two parallel shafts which rotated against each other. These shafts were provided with knives placed in such a manner that they formed a screw-thread. Fixed knives were also placed in the bottom and top covers.

Owing to a supply of cheap labour being available few improvements of note were made for many years other than those in machines for mixing, pulping and moulding the raw peat. In recent years, however, attention has been directed rather to the mechanical excavation and transportation of the peat in process of manufacture, and to the development of machinery for the continuous mechanical handling and treatment of the raw peat from the bog to the spreading-ground.

Description of Anrep Machine

The Anrep machine imported by the Department of Mines and employed on the Alfred bog in 1910-11, may be taken as fairly representative of the stage of development reached at that time. The machine consisted of an Anrep macerator with an elevator for raising the hand-dug peat from the bog and a rolling table for delivering the pulped peat to cars for spreading on the drying-field. The feed-hopper of the macerator was made narrower at the top and widened out towards the machine in order to prevent the peat mass from forming an arch, which otherwise frequently occurs with single shaft machines.

The cylinder, in which the shaft rotates, is made with two different diameters connected by a conical part. In the wider part below the feed hopper the shaft is provided with six double knives of the construction shown in Figure 5. These knives rotate against the six fixed knives inserted through the bottom of the cylinder which act as half-bearings for the shaft. The fixed as well as the rotating knives, in this part of the machine, are each of the same pattern and of exceedingly strong construction. In the conical part of the cover the shaft is supplied with a screw-thread which, with its sharp edges, cuts against the fixed knives on either side. The narrow cylinder has three fixed knives inserted through the bottom and two through the top which latter with the two corresponding knives through the bottom form full bearings for the shaft.

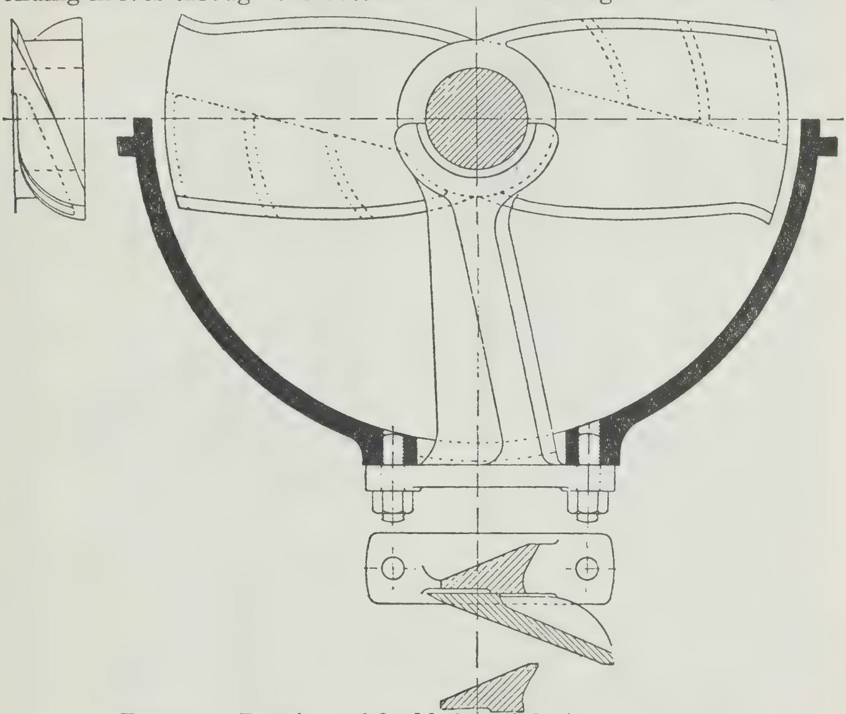


FIGURE 5. Rotating and fixed knives of the Anrep macerator

The shaft is furnished in this part with two knives and a double screw-thread, which, if desired, can be replaced by fixed and rotating knives, in case the peat requires a still more intensive pulping. In front of this cylinder is placed a conical part which carries the mouthpiece of the machine. The shaft in this conical part is provided with a double screw-thread, which presses the peat mass towards the mouthpiece.

The knives rotating under the feed-hopper have bill-shaped points, on which the descending peat falls during their upward motion. These bills tear the peat to pieces and throw it towards the opposite side of the cylinder, where it is caught again, and cut against the fixed knives. The shaft makes 260 revolutions per minute.

Every part of the macerator is easily accessible. By loosening a few bolts, the feed-hopper and the upper part of the larger cylinder can be turned on hinges and the mouthpiece and conical front piece are turned open in a similar manner.

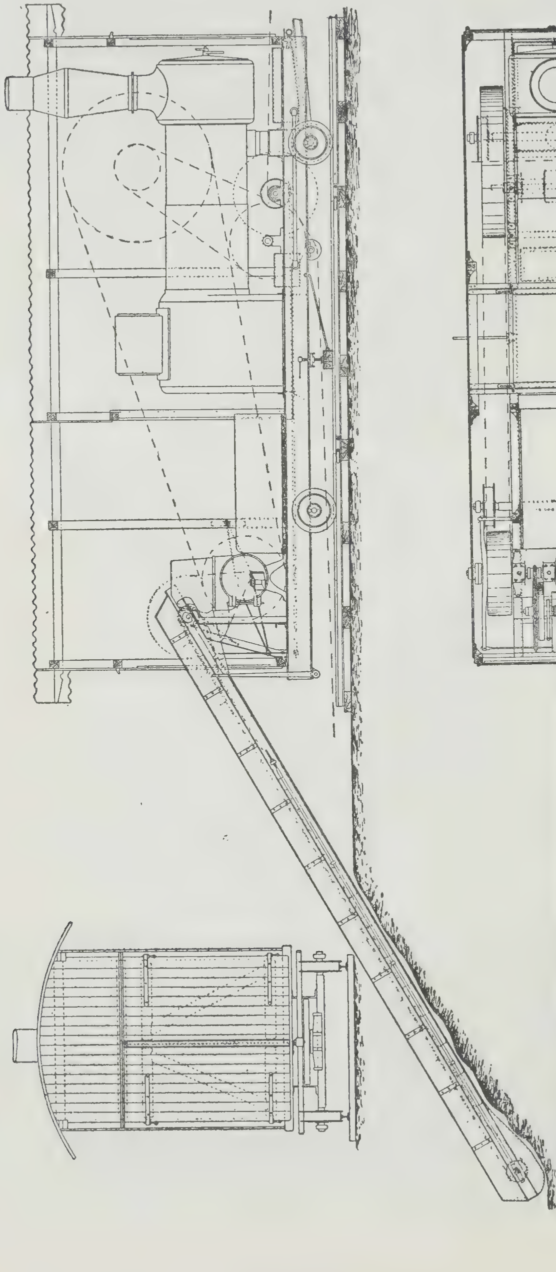


FIGURE 6. Elevator and rolling table used with Anrep peat machine

The elevator and rolling table generally used are shown in Figure 6. The former is a so-called drag elevator, without any special carrying arrangement at its lower end. It is made of channel beams and iron plates. The returning part of the chain with its pallets runs on a sheet-iron bottom under the elevator, which permits the elevator to rest on the steps of the trench, and decreases the lifting of the raw material to a minimum. The rolling table is placed at an angle with the centre of the peat machine, whereby the cars generally used for the transportation of the machined peat are more conveniently loaded.

As a rule, these machines are operated by a 42 h.p. motor, which is also sufficient for the operation of accessory apparatus.

RECENT DEVELOPMENT IN EUROPE

European operators in the peat fuel industry have in late years, devoted considerable attention to improvement of the mechanical means employed for the winning of peat. Several mechanical excavators of large capacity have been developed, chiefly of the endless chain and bucket type. Some of these, although efficient in the excavation of clear, root-free peat, are unsuitable for use in bogs where roots and trunks of trees are present to any extent.

Most of the existing peat excavators are designed to travel on the surface of the bog. On the other hand at Dumfries, Scotland, a floating dredge with pipe line attachment for conveying the wet peat has been employed. Ekelund, in Sweden, placed his excavator in the bottom of the working-trench on the soil from which the peat had been removed, a method rendered practicable in this particular instance by the fact that the bog was underlain by a stratum of firm sand.

The use of caterpillars to support and move machines on the bog has been only slightly developed. Owing to the extensive areas required for the air-drying of peat on large-scale production, the transporting and spreading of the raw peat on the drying-surface is a factor of economic importance, that has led to the adoption of various mechanical devices to reduce cost. The newer conveyers and spreaders, employed in Europe, are designed for the handling of pre-moulded peat blocks, which are automatically dumped on the drying-ground. Machines of this type are open to the objections that dumping of the wet peat blocks is more or less destructive of their form and appearance. Moreover, the mechanical limitations of the type of conveyer developed, unduly restrict the width of the drying-areas, thereby adversely affecting productive capacity of the machines.

The lines of development, in Europe, of machinery for winning peat may be exemplified by the machines devised by Dr. Wielandt, Strenge, Dolberg, Baumann-Schenck, Ekelund, and others.[1]

[1] For data relating to these machines and the accompanying illustrations, the writer is indebted to the British Fuel Research Board, in whose report for 1922-3 additional information with regard to them may be found.
Report of the British Fuel Research Board for the years 1922, 1923. First Section: The Production of Air-dried Peat, London, 1923.

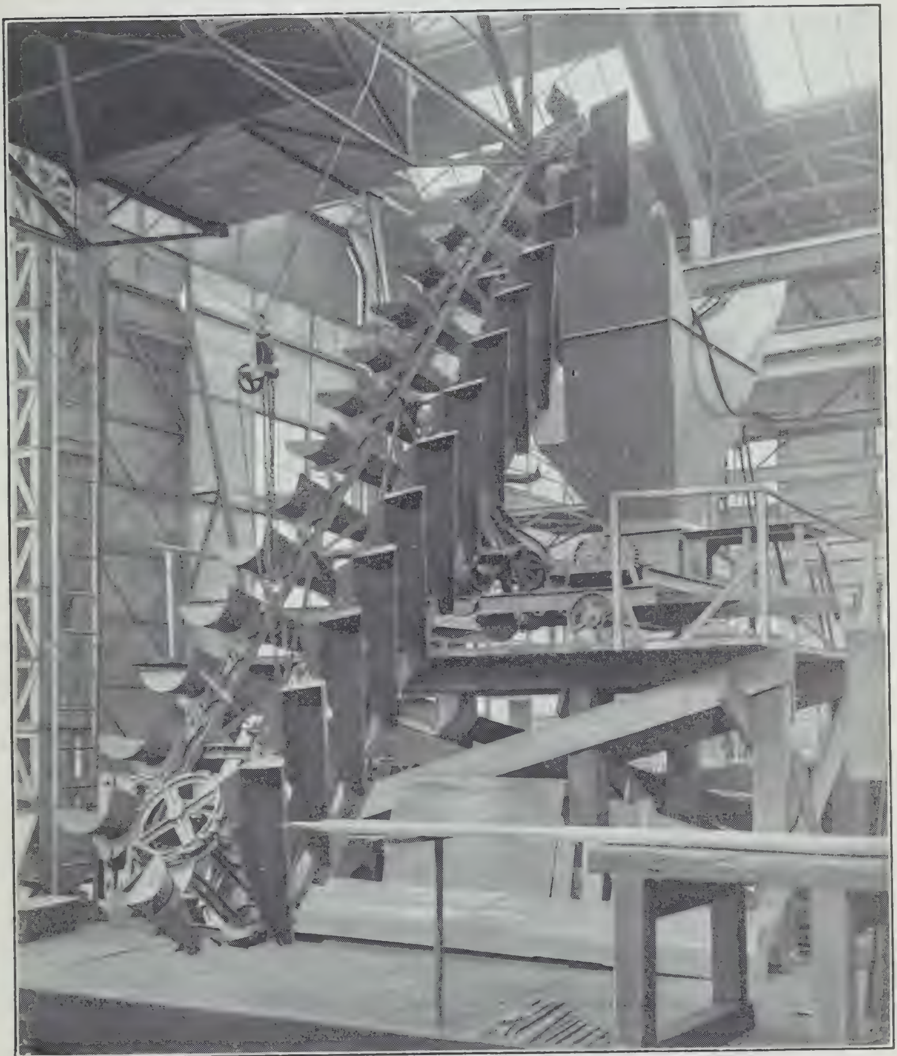
The Wielandt Peat Machine

A plant using this type of machine is in operation near Elizabethfehn, Germany, and provides a supply of air-dried peat for the manufacture of peat coke. The Wielandt automatic peat-winning machine consists of a mechanical excavator, a macerator with forming mouthpiece, and a sod transporter. The excavator and macerator are set on an under-carriage with flangeless wheels running in channel irons supported on wide timber sleepers about 5 feet in length. The excavator consists of a rotating chain of buckets (Plate I) which dredge the peat from a face sloping at 60 degrees. The buckets can be adjusted to vary the depth, width, and slope of the excavation. The width ordinarily excavated is 1·75 metres and the depth 2 to 2·5 metres. The slope of face may be varied from 45 to 75 degrees and the depth of the excavation from 1 to 4 metres. The chain carries 30 buckets, each 1·7 metres long, 25 centimetres in diameter at the outer end and 12·5 centimetres at the inner end, forming a half-truncated cone, and is driven through bevelled gearing from the shaft operating the macerator. The buckets have three teeth or knives fixed to the outer edge, and guides, which slip on light steel rails, attached at the back. A solid link chain operates shafts at the top and bottom of the dredge on which the sprocket wheels carrying the dredger chain are mounted.

The body of the macerator is formed of pressed steel plates with welded seams and contains two square shafts with right and left handed cast steel quadrant helices which revolve at 180 r.p.m., and as the peat is free from roots there are no fixed or rotating knives. The peat issues from the macerator through a forming mouthpiece in a stream of elliptical cross-section, 13 by 11 centimetres, and is received on a chain of conveyer plates moving with a velocity to correspond with that of the peat stream. As the stream issues it engages paddles, attached to a light wheel, which cut into the peat and make partings along which the blocks divide as they dry out.

The conveyer plates travel over a bridgework frame 42 metres in length, and are supported in a horizontal position by two longitudinal angle irons on which their inner and outer edges run. When the chain of plates is loaded for the entire length of the supporting frame, a pin in the chain engages a lever which drops the outer angle iron about six inches. Owing to the removal of the support of their outer edges the entire row of plates tip and deposit the peat blocks on the bog surface. The height from which the peat is actually tipped is not more than 35 to 40 centimetres. A row of plates is filled in regular operation in about 45 seconds. When the plates are freed from the weight of the peat, a number of spiral springs pull back the outer angle iron into place and restore the chain of plates to a horizontal position. The conveyer girder is carried on eight, light caterpillar supports, spaced 5 metres apart and moves forward as each row is laid on the field, the usual rate of movement being 9·5 metres per hour.

The plant is electrically operated by a 500-volt, 3-phase system, current being picked up by a 150-metre length of flexible cable connected to a supply line at posts set in the bog at suitable intervals. The macerator requires 20 h.p. and the other operations another 20 h.p. The power



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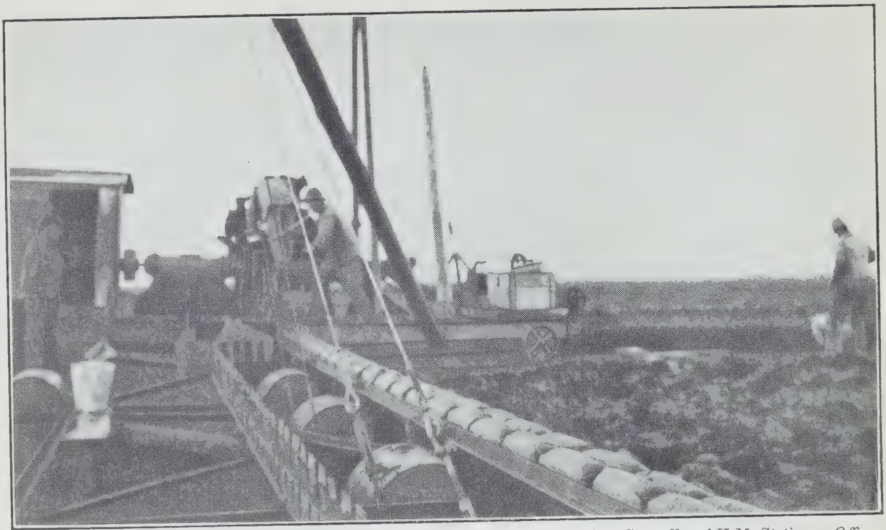
Excavator of Wielandt peat machine

Plate II



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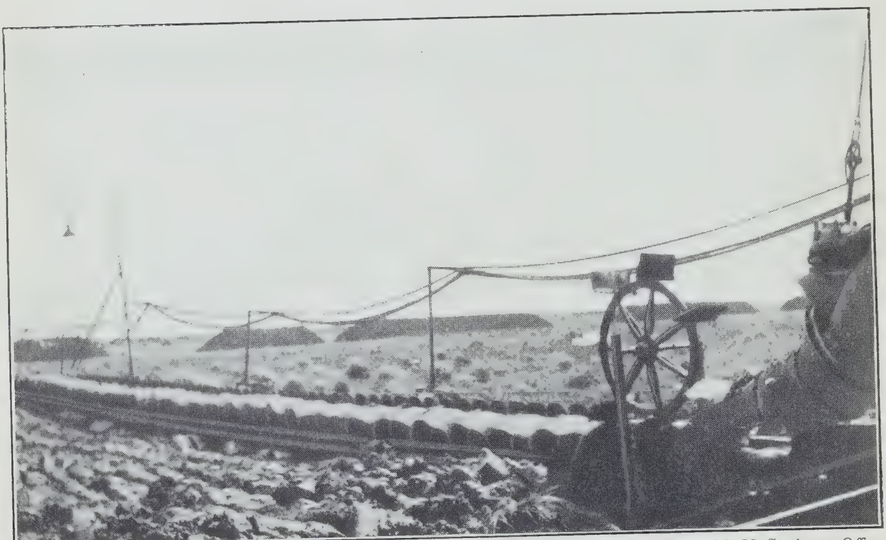
Strenge conveyer

Plate III



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Cross-cutting device and sod-carrier of Siemens-Strenge peat machine

consumed is said to average 5 kw. hours per ton of peat produced. Two men are employed shifting rails under the main machine, and two others operating the excavator and conveyer. The capacity of the machine is slightly over 5 tons of air-dried peat fuel per hour.

An excavator of this type would only be efficient on a bog containing peat free from roots and other obstructions. The same may be said of the macerator. An objection to the conveying and spreading system is the distortion of the peat blocks which results from their being dumped on the bog surface while in a soft and plastic condition. The width of the drying-area, and therefore the capacity of the machine, is restricted within narrow limits by this system. For these and other reasons it would probably be found unsuitable for use under conditions ordinarily present on Canadian bogs.

Light Pattern Strenge Automatic Machine

The principles of operation are in general similar to those of the Wielandt plant above described, but differences occur in details of construction. The excavator buckets are really scrapers 2 metres wide, formed of light, pressed steel plate, tipping at the top into a trough conveyer, which feeds the macerator. The machine excavates a section 2 metres wide by 1·75 metres deep from a vertical face.

The macerator has a double forming mouthpiece with a cross-cutting device and delivers a double stream of peat blocks to the conveyer plates. The conveyer is shown in Plate II. The conveyer consists of an endless chain of plates and is carried on 24 rollers, each 18 inches in diameter by 24 inches long, consisting of light, pressed steel drums. The conveyer is 35 metres in length. The conveyer plates are drawn along by a chain, and are kept in a horizontal position by a guide angle. When the plates are full for the entire length of the conveyer an automatic mechanism moves the guide angle horizontally free of the plates, which then tip automatically. The guide angle swings back to its original position and the plates continue around the conveyer in a vertical position. As they return to the macerator end, they come in contact with an inclined rail which restores them to the horizontal and enters them under the guide angle ready to be re-loaded. In this case the sods are turned completely over by the tipping of the plates. (Plate III).

The peat machine and conveyer are moved forward by a steel cable wound on a drum attached to the peat machine and passing through pulley blocks fixed to large anchors set into the bog about 100 metres ahead. A Strenge machine of this type was in use at the Scharrel Brickworks near Oldenburg, Germany, in July, 1921, and was electrically operated, the current being transmitted on overhead lines from the brickworks. The forward movement of the conveyer was about 10 metres per hour, giving an output of approximately 4½ tons of air-dried peat fuel per hour, and four men were required for operation.

Three Strenge machines were employed at the Fintlandsmoor Peat Works near Ocholt, Oldenburg, and were operated by power supplied from 25 h.p. steam engines and boilers fired with peat.

In a recent design, Orenstein and Koppel have adapted the Strenge excavator to bogs up to 6 metres in depth. (Plate IV.) The peat machine is kept back about 3 metres from the working-face, and the excavator, suspended from a jib, is made 4 metres wide and subdivided into four separate dredgers. Each dredger is 1 metre wide and removes a bench 1 metre wide by 1·5 metres high, the full slice removed by the excavator having a cross section of 6 square metres. It is hoped that by leaving the face stepped in benches 1·5 metres high by 1 metre wide, the 6-metre face exposed may be stable, but this is doubtful, and the mechanical difficulties inseparable from working four separate dredgers on the one shaft are obvious.

Siemens-Strenge Peat Machine

In 1921, four large-sized Siemens-Strenge excavators with automatic plate conveyers for spreading the peat, two large Dolberg-Strenge hand-fed elevators with plate conveyers attached, and six Dolberg hand-fed machines were employed in the production of 59,000 tons of peat at the Wiesmoor Electric Power Station in the Duchy of Oldenburg. (Plate V.)

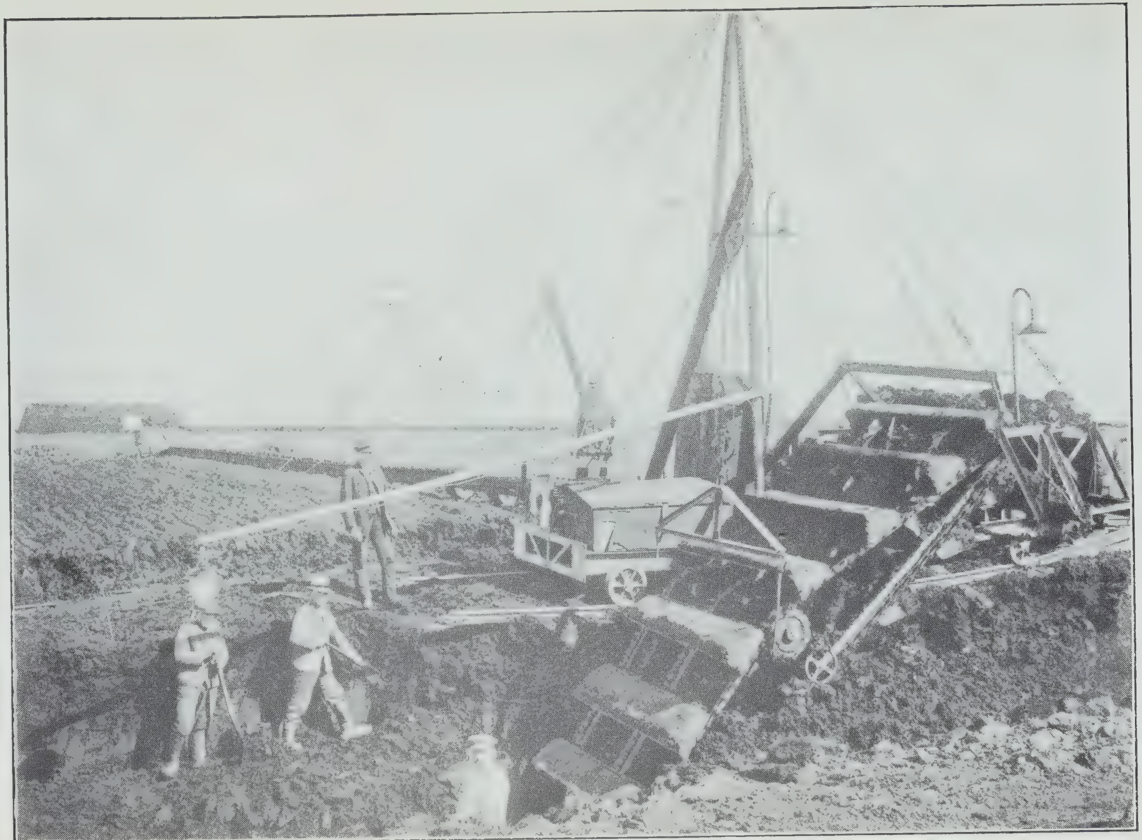
The Siemens-Strenge machines were originally designed by Strenge but have been improved by the Siemens Electrischo Betriebe. The complete machine, operated by nine men, weighs about 50 tons, and about 65 h.p. is required to work the plant. The sod-spreaders on the large machine are 70 metres long. One machine with a conveyer 100 metres did not prove successful.

The excavation is performed by a vertical bucket dredger supported on a horizontal shaft, the outer end of which is carried by a vertical frame supported on the bottom of the working-trench while the inner end rests on the peat machine, which travels on the surface of the uncut bog. The section excavated at Wiesmoor is 4·5 metres wide by only 1·75 metres deep.

The use of a plant of this type would be impracticable on a deep bog, since it would not be possible to sustain the heavy weight of the machines near the vertical edge of a deep bog, and it would be equally impossible to carry the outer support of the excavator element on the cutaway bog. When the excavation is proceeding at its maximum rate the 70-metre band of peat blocks is tipped once every 65 seconds. This would give an output of 102·5 cubic metres of raw peat per hour, corresponding to about 330 tons of air-dried fuel in 24 hours (13·75 tons per hour). Allowing for stoppages, it would not be safe to estimate the productive capacity of the machine higher than an average of 220 tons per three 8-hour shifts (9 tons per hour).

A large automatic Siemens-Strenge dredging machine has also been installed at Südmoslesfehn on the Hunte-Ems canal east of Oldenburg. The chain of buckets works vertically as at Wiesmoor, and excavates a section 6 metres wide by 2 metres in depth, advancing about 10 metres per hour. The machine is 130 metres long, of which the sod transporter accounts for 104 metres, with an effective length of 90 metres.

The output of this machine is said to be equivalent to 13 to 15 tons of air-dried peat per hour. It is served by from eight to ten men and requires five or six motors of a total capacity of 140 h.p., the power consumption being 1,000 k.w. hours per day. The machine is hauled forward by a motor winch mounted on a truck, 200 metres ahead of the plant.



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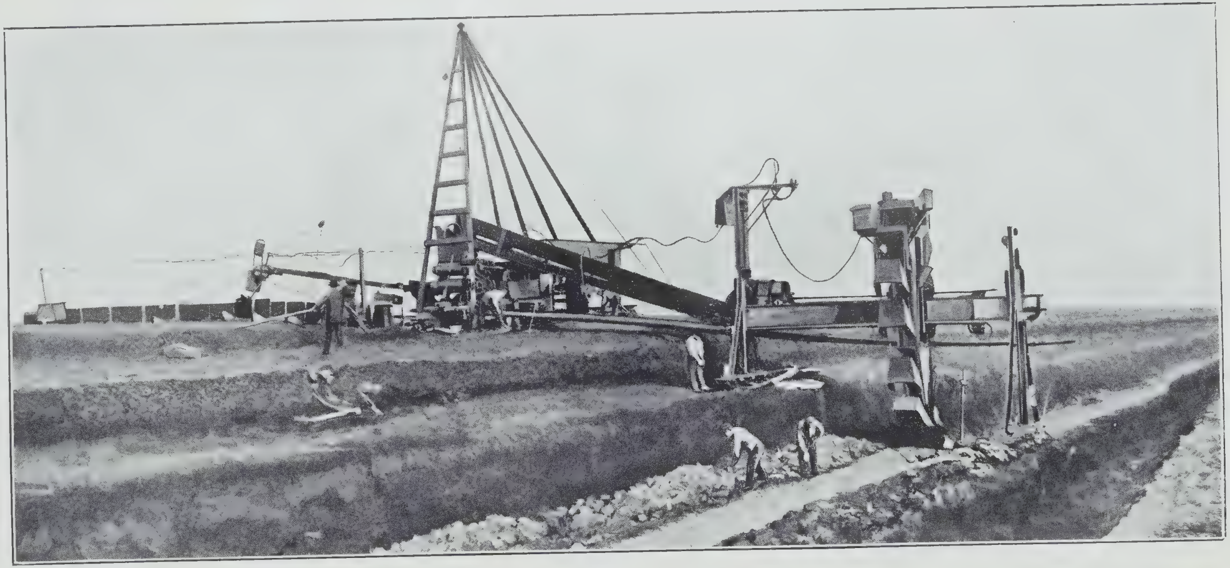
Electrically operated Strenge machine by Orenstein and Koppel

PLATE V



Siemens-Strenge peat machine employed on the Wiesmoor

The chain of plates has a speed of 90 metres per minute and tips every 50 seconds, but as the sods are tipped from a height of 20 inches they are badly damaged and deformed. It takes twenty men three and a half days to change the direction of the machine, and the first cost of the plant was high.

Dolberg Automatic Peat Machine

An inclined dredger is suspended from a counterweighted gantry, along which it may be traversed, and removes a slice from the sloping face of the bog, somewhat in the same way as the Anrep excavator on Plant No. 1 at Alfred. (Plate VI.)

The buckets are really scrapers and their front edge, which is curved and set at an angle, is kept very sharp. Attached to every fourth link in the dredger chain are sharp knives which make vertical cuts as they are drawn through the peat, and are able to cut through roots 2 or 3 inches in diameter or larger, if they are decayed. Fibre brooms at the head of the dredge-chain keep the knives free from clogging. The conveyer which has an effective length of 50 metres, is similar in general respects to those of Wielandt and Strenge, but embodies some improvements. (Plate VII.) It is built up in 10-metre lengths and when moving from one face to another, it can be dismantled into these lengths. Every third link of the chain of plates is supported on a small carriage with two wheels so that rolling friction is substituted for the sliding friction of the Wielandt and Strenge conveyers.

A machine of this type installed at Heiderfeld near Hamburg, Germany, is supplied with power by a 35 h.p. steam engine, which precedes it, the power being transmitted by a belt. The total weight of the machine, excluding the steam engine, is 23 tons.

Four men are required for operation, one firing the steam boiler, one driving the machine and operating the levers, and two men moving the rails and sleepers in advance.

The average output of the machine at Heiderfeld could not be placed higher than 4 tons per hour, but it is thought that this machine can be considerably improved.

Baumann-Schenck Automatic Peat Machine

Two of these machines are used on the Bavarian State Peat Works, Raubling, Upper Bavaria. Both the excavator carriage and the sod-spreader are mounted on caterpillar supports. A suspended excavator arm has a dredging length of about 11 metres which, operated at a slope of 40 degrees, permits of excavation to a depth of 6 metres.

Rotating on this arm is a chain of scraper buckets, and alongside it, working in a slide, are six wheels with radial arms, each arm bearing L-shaped cutting knives. These wheels and cutting knives rotate rapidly and at the same time move together in the slide, slightly upwards and downwards, so as to completely cover the exposed face. The knives are intended to cut the peat and any light timber which may be found in the bog. At the same time they locate heavy timber before the dredger encounters it and shearing pins are inserted which, by giving way, prevent any damage. The knives loosen the peat and push it into the track of the scrapers, by which it is elevated and tipped on to a conveyer that carries it to the macerator mounted on the main platform of the machine.

In the most recent design the wheels are about $1 \cdot 5$ metres in diameter, but in an earlier pattern, which is still working on the Raubling bog, there is only one cutting wheel of 2 metres diameter, which traverses up and down the whole length of the dredger arm.

Each peat block is formed separately and in a different manner from any of the other peat machines. The peat, as it issues from the mouthpiece of the macerator, enters a drum in which the blocks are moulded in separate radial sectors and placed on the plates of the conveyer. The conveyer may be increased in length from $26 \cdot 5$ metres to $106 \cdot 5$ metres by the addition of 20-metre sections, but the normal length is $66 \cdot 5$ metres, with an effective spreading length of 64 metres. The plates of the conveyer are 45 by 16 centimetres and run in a supporting girder 65 centimetres deep by 50 centimetres wide. The lower loaded chain travels at a height of about 60 centimetres above the surface of the bog and each plate is hinged, at the loading end, about an axis attached to the chain. The plates are kept horizontal by pins running on two guide rails and when the latter are withdrawn the plates swing downwards into vertical positions, tipping the peat blocks on to the bog. The cutter requires a 20 kw. motor and the excavator and other parts of the plant are driven by a 40 kw. motor.

The A. H. W. Automatic Peat-winning Machine

As employed at Rogestorps, Sweden, (Plate VIII), this machine is similar to the Wielandt machines used in Germany, excepting in details of construction. An Anrep-Svedala macerator is used, and the machine is electrically operated by a 50 h.p. motor direct-connected to the 1,600-volt, 3-phase hydro-electric supply for the district. The excavator is not suitable for use in bogs containing timber or roots. The output of the plant averages 4 to $4\frac{1}{2}$ tons of air-dried peat per hour over the whole season. The usual length of the peat-winning season at Rogestorps is from April 15th to July 20th. The light band appearing on the excavated face in the illustration is due to the bearing-plate, which helps to take up the unbalanced weight of the dredger, pressing against the working-face. A number of machines of this type are used in Norway and Sweden.

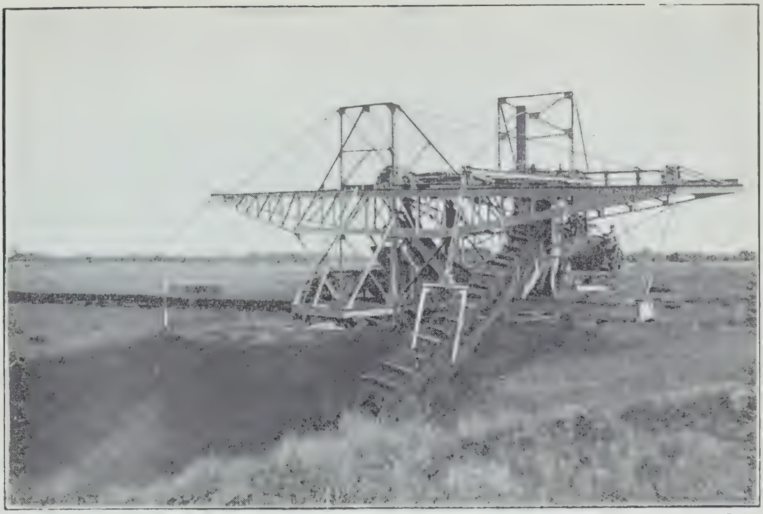
Persson's Conveyer

Many Swedish bogs contain so much buried timber that it is difficult to work an excavator of the dredger type. For this reason many Anrep hand-fed elevators are employed in conjunction with Anrep macerators and Persson's conveyers.

In the operation of this conveyer, pallets or short pieces of board loaded with raw peat, cut into lengths by hand as it issues from the mouthpiece, move over a roller table. When the loaded boards strike a trigger device a short section of the table sinks depositing them on two endless wire ropes by which they are carried out to the drying-field. Counterweights restore the table to position, in which it is held by the re-set trigger until the latter is again struck.

The conveyers are made in lengths of 100 to 200 metres, the usual length being 150 metres. They consist of two endless cables passing over rollers supported on trestles which are spaced 8 to 10 metres apart, and

Plate VI



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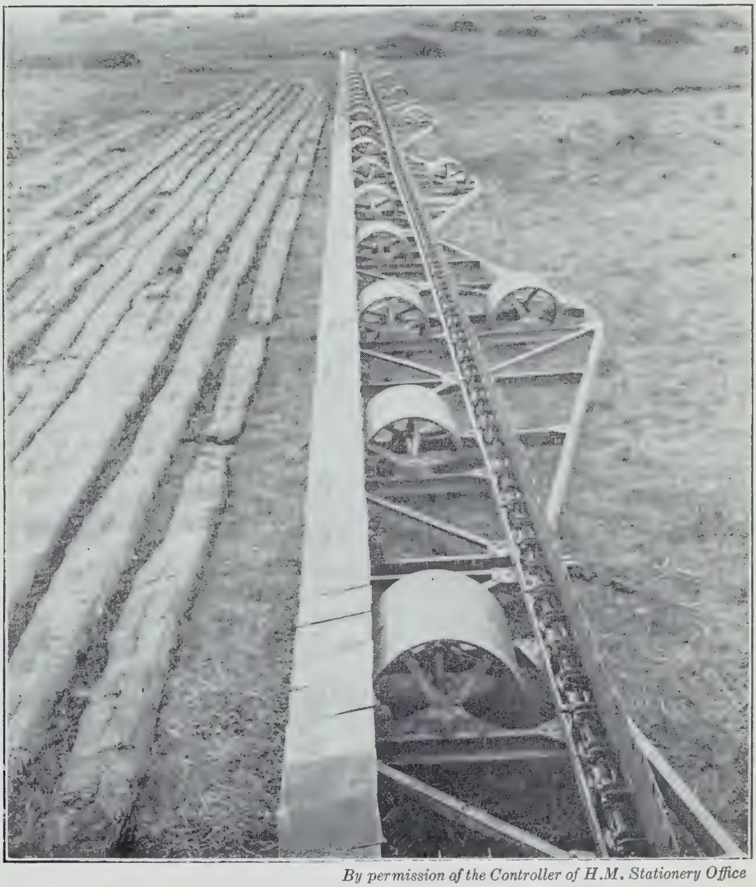
Dolberg peat machine

Plate VII



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Dolberg sod-conveyer

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A.H.W. automatic peat machine at Rogestorps, Sweden

are mounted on skids, so as to slide easily over the bog surface when the conveyer is moved forward. At the outer end of the conveyer, a weighted carriage running on rails and bearing-wheels, around which the cables pass, applies the required tension to the cables. The cable is operated from the peat machine, and the anchor carriage at the outer end is held in position by large anchor plates sunk in the bog. Guides, at intervals on the trestles, prevent the wind blowing the cables off the supports.

The boards loaded with peat are lifted off by hand in the field, the peat blocks tipped on to the bog surface, and the empty boards placed on the returning cables which bring them back to the machine where they are automatically lifted off the cables. The boards used are about 4 feet 6 inches long, 7 inches wide and 1 inch thick.

The row of peat spread from one position of the conveyer is of a width to contain about 25 boards of peat. Plants of the above type are usually electrically driven, and require the services of 7 or 8 men and a couple of boys, the output being 25 to 30 tons per 8-hour shift.

Ekelund-von Porat Excavator

The Ekelund-von Porat excavator employed at the Swedish State factory for the production of powdered peat fuel on the Hasthagen bog near Vislanda, presents an essential variation from the plants before described, in that the machine is located on the bottom of the bog from which the peat has been removed. (Plate IX.) It consists of a substantially built dredger chain with buckets, suspended from a jib attached to the main framework which is mounted on a turntable permitting excavation in any direction desired. The under-carriage with the turntable and rack is supported on rails. The peat from the buckets falls to the macerator in the base of the machine and, after being pulped, is elevated to tip-wagons running on rails on the surface of the bog near the excavation. When 12 wagons are filled they are hauled by an electric locomotive to the drying-ground and the peat tipped in heaps, 2 metres apart, from a temporary track. The heaps are then levelled off by a field-press to a layer 10 centimetres thick, and divided into separate blocks. The field-press consists of a bottomless box 2·2 metres wide with skids under the sides, and has fixed at its centre an inclined deflector like a snow-plough, which distributes the peat across the box. It is weighted, and hauled forward by a steel cable operated by a motor-driven winch mounted on anchor cars at either end of the spreading-ground. The layer of peat is divided into longitudinal strips by a double row of circular disks at 10-inch centres drawn along behind the box, and transverse cuts are made by a knife operated by a crank. Three men are required for operation of the press. As soon as rows of peat are tipped on both sides of the portable track it is lifted 2·7 metres to one side and laid down ready for the next row. Five separate motors are provided for operating the plant, one for each movement, those for excavating, turning, moving forward and elevating being 14 h.p. each, and for the macerator a 50 h.p. motor is provided, the maximum load at any one time being about 70 to 80 h.p. Eight men operate the excavating machine, and, working three 8-hour shifts, the output amounts to 128 tons of air-dried peat in 24 hours or 5·35 tons per hour.

CHAPTER III

PEAT RESOURCES OF CANADA

Peat deposits are widely distributed and cover large areas particularly in the northern portions of both Europe and America, where the climatic conditions have been most favourable to their formation. Since only a very small fractional part of such areas has been submitted to detailed investigation, estimates of the extent and workable contents of peat bogs as a whole must, for the most part, be regarded merely as rough approximations.

In a lecture before the Royal Dublin Society, Professor P. F. Purcell included the following table as giving the areas of peat deposits of various countries according to the best information available[1]

TABLE IX

Areas of Peat Bogs of Various Countries

Country	Area in square miles
Great Britain	9,400
Ireland	4,700
United States	11,200
Canada	37,000
Sweden (2,000 square miles peat fuel bogs)	19,200
Norway	2,900
Denmark	400
Germany	9,900
Austria	1,500
Russia	65,000
Finland	38,000

C. A. Davis[2] estimated that 11,188 square miles of peat bogs in the United States, with an average possible production of 200 tons of dry fuel per acre-foot, and an average depth of 9 feet, had a potential productive capacity of 12,888,500,000 tons of fuel. Soper and Osbon[3] state that recent field investigations seem to justify an increase of this figure to 13,827,000,000 tons.

Dr. R. Chalmers[4] in his Bulletin on Peat, gives a summary of the peat areas of Canada as follows:

TABLE X

Estimated Area of Canadian Peat Bogs

Province		Square miles	Average depth in feet
Nova Scotia		250	8 to 10
Prince Edward Island		10	8 to 10
New Brunswick		250	8 to 10
Quebec (in settled parts)		500	8 to 10
Ontario (in settled parts)	450		
Ontario (Moose River basin, etc.)	10,000		
		10,450	5 to 8
Manitoba		500	6 to 10
Alberta, Saskatchewan, and Territories		25,000	5 to 10
British Columbia and Yukon territory		no data	
Total in round numbers		37,000	

[1] The Peat Resources of Ireland, by Prof. Pierce F. Purcell, British Fuel Research Board, Special Report No. 2, 1920.

[2] The Uses of Peat for Fuel and other Purposes, by Chas.A. Davis—U.S.Bureau of Mines,Bulletin No.16, 1911.

[3] The Occurrence and Uses of Peat in the United States, by E. K. Soper and C. C. Osbon U.S., Geol. Surv., Bull. 728.

[4] Bulletin on Peat by R. Chalmers, Geological Survey of Canada, 1904.

Estimated on a basis similar to that employed by Davis for the United States, Canadian peat bogs would represent a potential fuel resource of nearly 35,000,000,000 tons. The value of an estimate so based is, however, materially affected by various considerations. Large areas of the bogs of the western provinces of the Dominion contain peat which is only poorly humified, or is otherwise unsuitable for fuel production by any existing process of manufacture. Moreover the existence of vast deposits of coal stretching from the vicinity of Estevan, Saskatchewan, to the Rocky mountains, and extending along their eastern flank for 600 miles in Canadian territory, and varying from low-grade lignites to coals that approach anthracite in carbon content, makes the fuel potentialities of the peat bogs of the northwest provinces a matter of comparatively remote consequence. It is more particularly in the central provinces of Ontario and Quebec, which are devoid of coal measures and therefore largely dependent upon foreign sources of fuel supply, that the development of the numerous peat bogs strategically distributed throughout their settled portions assumes practical importance.

In order to ascertain more accurately our peat bogs most likely to be immediately available for fuel production, the Mines Branch of the Federal Department of Mines began in 1908 an investigation of the more important peat deposits convenient to centres of population and favourably situated as regards transportation. This investigation has been continuously carried on since then, and up to the end of the summer of 1921, one hundred and seven bogs comprising 228,367 acres and estimated to be capable of producing 198,226,000 tons of peat fuel with 25 per cent moisture and 13,650,000 tons of peat litter, had been surveyed and mapped. Not only have the location and extent of these bogs been ascertained, but their depths, quantity and quality of workable peat contents and other factors affecting their value for the commercial production of fuel and litter have been determined. Much of the information gained during the earlier period of the investigation has been published in a series of bulletins issued by the Mines Branch, and the more recent reports of A. Anrep, by whom the investigations have been conducted, have been included in the Annual Summary Reports of the Geological Survey, Department of Mines.

Table XI shows approximate areas, depths, quantity of workable peat, and estimated possible production of fuel and moss litter from bogs in Canada, which have been investigated.

TABLE XI

Locations, Areas, Contents, and Estimated Possible Production of Fuel and Litter from Investigated Bogs in Canada

Peat Bogs	Approx. area	Less than 5 ft. deep	5 to 10 ft. deep	10 to 15 ft. deep	Over 15 ft. deep	Approx. contents	Estimated workable volume	Estimated possible production of fuel with 25% moisture	Estimated possible production of litter with 20% moisture	County or district
	acres	acres	acres	acres	acres	Cu. yds.	Cu. yds.	tons	tons	
ONTARIO										
Mer Bleu	5,000	1,564	2,237	856	347	56,050,700	38,440,000	5,126,000	...	Russell
Alfred	6,800	1,386	3,084	1,316	1,014	100,182,450	70,270,000	9,369,000	...	Prescott
Welland	4,900	1,435	2,877	588	...	50,975,000	30,796,000	4,106,000	...	Welland
Newington	3,800	887	1,191	748	974	62,913,800	46,566,000	6,209,000	...	Stormont
Perth	3,800	638	958	2,098	106	55,523,000	38,445,000	5,126,000	...	Lanark
Victoria Road	67	36	15	12	4	638,700	400,000	54,000	...	Victoria
Brunner	2,290	1,260	1,030	...	...	15,687,500	8,790,000	1,172,000	...	Perth
Komoka	900	605	295	...	...	4,786,700	1,900,000	254,000	...	Middlesex
Brockville	1,400	356	475	490	79	18,601,500	12,705,000	1,694,000	...	Leeds
Rondeau	1,570	958	316	207	89	13,985,000	7,856,000	1,047,000	...	Kent
Holland	14,640	9,084	4,025	1,025	506	123,592,000	61,640,000	8,219,000	...	Simcoe & York
Coney Island	25	...	25	...	...	322,600	240,000	32,000	...	Kenora
Crozier	355	...	...	355	...	8,063,000	6,910,000	...	518,000	Rainy River
Fort Francis	1,700	923	691	86	...	14,293,000	6,680,000	891,000	...	"
Richmond	5,500	3,340	2,160	...	...	62,777,000	20,908,000	2,788,000	...	Carleton
Luther	4,900	1,000	1,650	1,700	550	73,143,000	55,820,000	7,443,000	...	Dufferin
Amaranth	500	275	225	...	...	4,310,000	1,978,000	264,000	...	"
Durham	40	...	...	...	...	...	...	...	...	Grey
Cargill	6,600	...	...	...	...	...	...	...	...	Bruce
Westover	1,400	1,045	355	...	...	8,411,000	2,290,000	306,000	...	Wentworth
Marsh Hill	5,100	1,018	1,446	1,267	1,369	91,214,000	72,156,000	9,260,000	...	Ontario
Sunderland	580	240	340	...	...	4,999,000	2,740,000	366,000	...	"
Manilla	745	380	355	10	...	6,611,000	2,990,000	399,000	...	Victoria
Stoco	1,285	361	666	230	28	...	10,086,000	1,345,000	...	Hastings
Clairview	280	280	...	...	...	451,700	...	...	...	Lennox & Addington

Tweed	50		50							Hastings
Buller	100		100							"
Moose Creek	12,000						94,770,000	12,637,000		Stormont, Russell, Prescott
Westmeath	2,745						20,080,000	2,773,000		Renfrew
Meath	1,695						13,492,000	1,799,000		"
Thedford	3,550		3-6 ft.				11,697,000	1,560,000		Lambton
Nellie Lake	3,090		4-11 ft.				24,916,000	3,322,000		Nipissing
Drinkwater	250		3-12 ft.				1,963,000	261,000		"
Cochrane	890		5-14 ft.				11,588,000	1,545,000		Timiskaming
Brower	2,220		5-8 ft.				11,584,000	1,544,000		"
St. John	2,050		4-8 ft.				10,043,000	1,339,000		"
Maybrooke	1,280		4-10 ft.				11,650,000	1,553,000		Nipissing
Beverly	1,730		3-5 ft.				2,033,000	271,000		Wentworth
Halton	480		3 ft.				1,548,000	207,000		Halton
Aberfoyle	300		4-6 ft.				1,049,000	137,000		Wellington
Pelee Point	6,010		2-15 ft.				36,302,000	4,840,000		Essex
Harrowsmith	380		4-20 ft.				3,599,000	480,000		Frontenac
Arthur	1,475	543	932			13,146,000	7,518,000	1,003,000		Thunder Bay
William	1,790	927	863			14,225,000	6,962,000	928,000		" "
Twin Cities	995	897	98			5,126,000	791,000	105,000		" "
Verona	6,830	1,426	2,121	1,881	1,402	106,451,000	79,768,000	10,636,000		Addington & Frontenac
	124,087							112,410,000	518,000	

TABLE XI—Continued

Locations, Areas, Contents, and Estimated Possible Production of Fuel and Litter from Investigated Bogs in Canada—
Continued

Peat Bogs	Approx. area	Less than 5 ft. deep	5 to 10 ft. deep	10 to 15 ft. deep	Over 15 ft. deep	Approx. contents	Estimated workable volume	Estimated possible production of fuel with 25% moisture	Estimated possible production of litter with 20% moisture	County or district
	acres	acres	acres	acres	acres	Cu. yds.	Cu. yds.	tons	tons	
					QUEBEC					
Large Tea Field	5,270	1,960	2,130	1,180	....	56,335,000	36,179,000	4,824,000	....	Huntingdon
Small Tea Field	4,190	1,800	1,530	860	....	41,250,900	24,866,000	3,316,000	....	"
Lanoraie	7,500	3,966	2,830	500	204	72,627,700	35,636,000	4,751,000	....	Berthier & Joliette
St. Hyacinthe	3,890	1,394	1,390	1,074	32	44,026,300	27,490,000	3,665,000	....	St. Hyacinthe & Bagot
Riviere du Loup	7,220	893	1,500	2,900	1,927	140,425,000	19,360,000 } 94,579,000 }	12,611,000	1,928,000	Temiscouata
Cacouna	845	262	215	264	104	15,290,000	8,343,000	....	626,000	"
Leparc	615	124	148	239	14	7,458,100	5,370,000	716,000	....	"
St. Denis	315	34	63	77	141	7,127,000	6,003,000	....	388,000	Kamouraska
Riviere Ouelle	4,520	802	879	919	1,920	90,268,000	36,440,000 } 21,910,000 }	2,921,000	2,624,000	"
L'Assomption	1,565	263	722	555	25	16,809,000	13,200,000	1,760,000	....	L'Assomption
St. Isidore	1,230	....	....	....	....	....	16,817,000	2,242,000	....	Laprairie, Napierville & Chateauguay
Holton	6,180	2,703	3,477	....	....	51,050,000	22,400,000	2,999,000	....	Chateauguay, Napierville & Huntingdon
Farnham	5,100	....	....	....	....	....	59,814,000	7,975,000	....	Iberville & Missisquoi
Canrobert	2,000	....	....	....	....	....	36,260,000	4,835,000	....	Rouville
Napierville	7,200	....	....	....	....	....	48,980,000	6,530,000	....	Napierville
Girard	3,105	....	....	....	....	....	26,539,000	3,539,000	....	St. John's & Napierville

Pont Rouge	125						524,000	69,000		Portneuf
Clair	2,600	758	882	916	44		25,333,000	3,377,000		Bellechasse
St. Joseph	1,550						14,576,000	1,944,000		Dorchester
Isle Verte	540						5,406,000	721,000		Temiscouata
St. Arsene	2,161						11,422,000 8,492,000	1,132,000	856,000	"
St. Anaclet	3,250						3,691,000 3,807,000	508,000	278,000	Rimouski
St. Luc	5,680		3-7 ft.				19,925,000	2,657,000		Champlain
Sagamite	340	79	112	76	73		3,606,000	461,000		Quebec
Breakeyville	1,780	1,066	623	91			7,499,000	1,000,000		Levis
Ste. Jean	270	150	120				1,694,000	225,000		"
Ste. Therese	1,070	1,070					3,453,000	460,000		Terrebonne
	80,110							75,238,000	6,700,000	

NEW BRUNSWICK

Seeley Cove	125	74		49	12–20 ft.		1,297,000	24,000	84,000	Charlotte
Pennfield	70						271,000		20,000	"
Hunter	95		3–10 ft.				834,000	111,000		"
Pocolagan	350	245	5–7 ft.	105	12–16 ft.		3,190,000	180,000	139,000	"
Musquash	290						2,714,000		204,000	St. John
Hayman	60		3–17				834,000	83,000		Charlotte
St. Stephen	155	82	3–12	71	12–30 ft.		2,262,000	63,000	135,000	"
Canaan	880		4–13				7,202,000		540,000	Westmorland
"A"	50		3–14				290,000	39,000		"
"B"	105		4–16				832,000		62,000	"
Hick's	250		4–20				2,868,000		210,000	"
Gades	825		4–22				9,838,000		737,000	"
Cudmore	350						1,788,000		134,000	"
	3,605							500,000	2,265,000	

TABLE XI—Concluded

Locations, Areas, Contents, and Estimated Possible Production of Fuel and Litter from Investigated Bogs in Canada—Concluded

Peat Bogs	Approx. area	Less than 5 ft. deep	5 to 10 ft. deep	10 to 15 ft. deep	Over 15 ft. deep	Approx. contents	Estimated workable volume	Estimated possible production of fuel with 25% moisture	Estimated possible production of litter with 20% moisture	County or district
	acres	acres	acres	acres	acres	Cu. yds.	Cu. yds.	tons	tons	
NOVA SCOTIA										
Caribou	890	345	215	130	200	10,789,000	5,815,000 } 1,960,000 }	362,000	349,000	Kings
Cherryfield	160	27	46	30	57	2,796,000	2,240,000	299,000	.....	Lunenburg
Tusket	235	82	105	48	.....	2,576,000	1,936,000	258,000	.....	Yarmouth
Makoke	460	120	240	100	.....	5,445,000	3,560,000	475,000	.....	"
Heath	2,175	825	1,212	134	4	21,419,000	1,384,000 } 13,350,000 }	1,646,000	104,000	"
Port Clyde	1,665	954	552	159	.....	13,690,000	7,560,000	1,021,000	.....	Shelburne
Latour	850	273	420	157	.....	8,855,000	5,660,000	755,000	.....	"
Clyde	2,240	1,390	520	180	150	18,225,000	11,595,000	2,127,000	.....	"
	8,675	.....	.....	.....	.....	.....	.....	6,943,000	453,000	
PRINCE EDWARD ISLAND										
Black Marsh	550	.....	.....	.....	.....	.....	1,370,000	183,000	.....	Prince
Portage	775	267	360	110	38	8,719,000	6,220,000	500,000	184,000	"
Miscouche	2,900	2,411	386	103	.....	14,298,720	4,940,000	415,000	137,000	"
Muddy Creek	60	60	.....	.....	.....	.....	347,000		.....	"
Black Banks	885	255	180	215	235	14,413,000	11,180,000	.....	839,000	"
Mermaid	185	83	94	8	.....	1,459,000	960,000	115,000	.....	Queens
	5,355							1,213,000	1,160,000	

MANITOBA

Lac du Bonnet..	250	180	70	....	....	1,258,400	445,280	59,000	....	Tp 14, R. 10 E prin.mer.
Transmission....	1,375	1,375	....	....	....	10,648,900	7,022,840	936,000	....	Tp 15, R. 12 E
Corduroy.......	100	....	....	....	....	649,000	322,660	43,000	....	Tp 15, R. 12 E
Boggy Creek....	660	....	....	....	....	....	4,257,050	568,000	....	Tp 15, R. 12-13 E " "
Mud Lake.......	140	....	140	....	....	2,011,700	1,564,630	209,000	....	Tp 15, R. 14-E " "
Litter...........	110	....	28	40	42	2,116,500	1,389,740 361,390	48,000	104,000	Tp 15, R. 14 E " "
Julius...........	3,900	1,000	1,954	946	....	44,382,500	32,651,750	....	2,449,000	Tp11-12, R .10 E " "
	6,535	....	....	....	....	....	....	1,863,000	2,553,000	

TOTALS

							Est. peat fuel 25% moisture	Moss litter		
46 Ontario.....	124,087	....	....	....	....	....	112,153,000	518,000	....	
27 Quebec......	80,110	....	....	....	....	....	76,137,000	6,698,000	....	
13 New Brunswick......	3,605	....	....	....	....	....	499,000	2,268,000	....	
8 Nova Scotia	8,675	....	....	....	....	....	6,361,000	453,000	....	
6 P.E.I.......	5,355	....	....	....	....	....	1,213,000	1,160,000	....	
7 Manitoba...	6,535	....	....	....	....	....	1,863,000	2,553,000	....	
107	228,367 acres	....	....	....	....	....	198,226,000	13,650,000	....	

PEAT IN NORTHERN ONTARIO AND NORTHERN QUEBEC

Very extensive areas of peat lands, as yet unexplored, occur in northern Ontario and northern Quebec along the line of the Canadian National railway and northward to the shores of Hudson bay. The extent of these peat bogs is enormous. They cover thousands of square miles and in fact occupy practically the entire region of the coastal plain, except on the borders of the rivers. No detailed investigations have been made of the depth of these bogs, but they vary from a few inches to probably 25 or 30 feet. On the smaller rivers, beds of peat from six to ten feet deep are in many places seen along the banks above the drift.[1] The deposits cover the entire region for 100 miles around the south and southwest sides of Hudson bay. The northerly 100 miles of the Nipissing-Algoma boundary line traverses an almost continuous tract of this kind.[2] From the slight information available it appears quite probable that large areas may contain peat of good quality. Deposits over eleven feet deep, resting on a clay floor, have been reported by explorers to occur in the Abitibi district[3] and samples from different points in that region and the Mattagami valley, which have been subjected to analysis, compared favourably with peat from bogs in the most southerly portions of Ontario. The existence of these sources of potential fuel supply may in the future prove a very important factor in the development of an extensive area of country in the Hudson Bay basin.

[1] Report on Moose River Basin, by J. M. Bell, Bureau of Mines, Ontario, 1904.
[2] The Nipissing-Algoma Boundary, by W. A. Parks, Bureau of Mines, Ontario, 1899.
[3] Agricultural Resources of Abitibi, by Archibald Henderson, Bureau of Mines, Ontario, 1905.

CHAPTER IV

EFFORTS TO ESTABLISH A PEAT FUEL INDUSTRY IN CANADA UP TO 1918

Before the outbreak of the war in 1914 numerous attempts to manufacture peat fuel commercially had been made in Canada. Various processes involving the employment of artificial heat and mechanical pressure were tried out. Failure and loss of the money invested resulted in every instance, and large sums, estimated at upwards of a million dollars, were wasted in these fruitless efforts.

Several attempts had also been made to manufacture machine-peat fuel by the air-drying process, and although a few thousand tons had been produced by this method, satisfactory machines for carrying out the various steps of the process were not at that time available.

In 1864 a plant for the manufacture of peat fuel was established near Bulstrode, Quebec, by James Hodges, an English engineer.[1] The raw peat was excavated by two large screw augers mounted on the front of a scow. As the scow moved forward it dug a channel 19 feet wide and 6 feet deep. The excavated peat was passed through a pulping machine, and spread on the adjacent bog in a strip 9 inches deep and 90 feet wide. As soon as dry enough this strip was cut into blocks 18 by 6 by 9 inches, and when firm enough to be handled, the blocks were stacked for further drying in the open air.

Tests of the fuel were made on locomotive engines, with results which were regarded as satisfactory. As a result of these trials a contract was entered into for a supply of peat fuel to the Grand Trunk Railway for a period of five years, which after the first year was to be at the rate of 300 tons per day. For various reasons it was found impossible to carry out the contract. The excavating device had serious defects, the pulping was imperfect, producing a bulky fuel poorly adapted to stand handling, and the system of drying large blocks of raw peat in stacks involved too much labour in handling and resulting in uneven drying and an inferior product.

Experimental work was continued for a number of years at St. Hubert, Chambly district, and at Ste. Brigide near St. Johns on the Richelieu river. Two of Hodges' machines were operated at St. Hubert and one at Ste. Brigide, and produced in 1875 about 13,000 tons of fuel. During the previous year, they are said to have produced 20,000 tons, the greater portion of which was sold to the Grand Trunk Railway.[2]

The inferior quality of the fuel produced by Hodges' methods, and especially the unevenness of drying obtained, led to efforts being made to extract water from the raw peat by mechanical pressure and the employment of artificial heat.

David Aikman, who had been superintendent of the operations of Hodges' machines for nine years, substituted for them an apparatus of his own invention by which the raw peat, pulped and freed of fibres, was mechanically pressed to expel a portion of the water, and afterwards moulded and dried in the open air, but his efforts ended in failure.

[1] Peat Fuel—Mode of Manufacture and Machinery Used in Hodges' Patent Process, by James Hodges, 1867.
[2] Catalogue of the Minerals, Rocks and Fossils of Canada, by B. J. Harrington, 1878.

In the early nineties there was a marked revival of interest in peat fuel and numerous enterprises were started during a period of several years mostly with a view to the manufacture of briquettes. This activity had its origin in the success achieved in Germany in the briquetting of brown coal and coal screenings. By 1900 the coal briquetting industry had already reached large proportions in Germany, the output for 1901 being over 1,600,000 tons.

Owing to failure to appreciate the great economic differences between the handling of a raw material such as brown coal with 50 to 60 per cent of water and peat which usually had a water content of 85 to 90 per cent or upwards, and especially through lack of knowledge of the peculiar properties of peat which render extraction of water from it by mechanical means very difficult and even impossible beyond a certain extent, it was thought that the methods successfully employed in dealing with brown coal, could equally well be applied to the production of fuel briquettes from peat.

Efforts along this line in Europe were continued for several years without success, and in 1901 only four small plants were operating, two in Germany, one in Russia, and one in Holland.

MANUFACTURE OF PEAT BRIQUETTES IN CANADA

Numerous companies were formed in Canada to manufacture fuel from raw peat by the simple process of drying and briquetting which had been successfully applied to brown coal in Europe.

The process consisted of (1) excavating, (2) drying, and (3) compressing. Various methods of carrying on all these operations were adopted.[1]

Excavating

At the Welland bog the surface was harrowed, and when a thin layer of surface peat (about $\frac{3}{4}$ inch) had been air-dried to a water content of about 45 per cent, it was scraped by hand to light railways laid on the bog at convenient distances, loaded into cars, and carried to the briquetting plant for further treatment. Five men with one horse were able to gather about 3,000 cubic feet of air-dried peat daily which would yield about 23 tons of finished fuel containing 15 per cent water.

At Beaverton an electrically-driven digger, the invention of Alex. Dobson, was employed. This consisted of a platform 7 by 10 feet, mounted on four wood-faced wheels with an 18-inch face to provide the large bearing surface necessary for operation on the bog. Supported on this platform and overhanging the ditch was a combined excavating and elevating mechanism, free to swing in a vertical plane about the upper sprocket-wheel shaft, and capable of being raised or lowered according to the depth of the cut to be made, the maximum depth being 4 feet. The excavating element scraped off a thin slice of peat and elevated it to a conveyer running across the front of the carriage, from which by means of a paddle wheel running at high velocity, it was showered over the surface of the bog to a distance of 30 to 50 feet, forming a thin deposit of finely divided material, in favourable condition to be dried by wind and sun. Successive layers up to 6 inches in depth could be deposited at intervals without materially

[1] Peat Fuel, its Manufacture and Uses, by W. E. H. Carter, Ont. Bureau of Mines Rept., Vol. XII, 1903.

affecting the drying process. The material so deposited was, when sufficiently dry, scraped and collected as at Welland. Under the best conditions a layer of distributed peat 1 to $1\frac{1}{2}$ inches deep would dry down from 85 to 45 per cent moisture in about $2\frac{1}{2}$ hours.

Wet weather seriously retarded operations, and in actual practice the air-dried peat collected by the methods described still had an average moisture content of 50 to 60 per cent according to weather conditions.

Drying

The further reduction of the moisture content of the peat to 15 per cent required for briquetting was a crucial feature of the process, and one of the main causes of break-downs. Several forms of drier were tried, but without economic success. The Simpson peat-drier used at Welland consisted of two parallel revolving sheet-iron cylinders 30 feet long, one above the other and fitted on the inside with cleats or shelves for lifting and stirring the peat as the cylinders revolved. The space between the upper and lower cylinders was occupied by a conveyer pan forming a third compartment. The gases of combustion from the firebox in front of the drier passed along the outside of the cylinders heating the peat, but never coming in contact with it. Dobson's drier consisted of a single revolving cylinder 30 feet long by 3 feet in diameter, set at a slight pitch and encased in brickwork. The combustion gases from the firebox which was built as a separate structure at the front end, passed around the exterior of the cylinder to its farther end, and then passed back through the interior of the cylinder meeting the peat the travel of which to the discharge end of the drier was facilitated by a slight inclination of the cylinder from the horizontal.

Briquetting

The Dickson peat-press which was the first to be employed in Ontario, was of the open-tube type used in Europe for the production of brown coal briquettes. The principle of this press lies in the fact that if a tube of indefinite length be fed with any material, the resistance due to friction between the material and the tube walls will gradually rise until no more can be forced in. Owing to its nature, when peat is caused to pack in a tube, continued pressure generates great increase in frictional resistance. For a die or tube $2\frac{1}{2}$ inches in diameter, a length of about one foot will give a frictional resistance equal to a pressure of 8 tons per square inch on the punch.

In operation the consumption of power required to expel the briquettes from the die was excessive. To ensure sound briquettes from the lighter peat the tube had to be of such length that when filled with denser peat the resistance was greater than required, leading to heating of the tubular die, wear on its inner surface, and consumption of unnecessary power, all of which resulted in frequent breakages. Water-jacketing devices to prevent overheating failed to overcome the difficulty. Several Dickson presses were installed and a number of companies formed with the intention of using them, but after numerous fruitless attempts, the plants already in operation were abandoned. The Dobson press employed at Beaverton and elsewhere was of the resistance block type. Friction was as far as possible eliminated, each die, previous to being recharged, being oiled to prevent friction of the peat against the die wall. It was estimated that the total pressure exerted by each punch was about 50 tons or with a briquette

diameter of $2\frac{1}{4}$ inches, about $12\frac{1}{2}$ tons to the square inch. Each briquette remained under pressure for about 6 seconds, and was then subjected to a second compression by formation of another briquette on top of it, after which it was expelled, the second briquette taking its place. Operation of the press was continuous, producing 100 briquettes per minute with 10 dies. Twenty-five briquettes weighed about 10 pounds, consequently the output of a press in 10 hours was about 12 tons of finished fuel.[1]

None of the attempts to manufacture briquettes passed the experimental stage. Owing to exceptional conditions at the Beaverton bog, a few hundred tons of briquettes were made and sold. But all the projects eventually failed. The chief difficulty encountered was in the drying of the raw peat preparatory to briquetting. At the outset it was thought that peat could be prepared for briquetting by air-drying alone, but it was found that briquettes could not be made of sufficient density.

The numerous failures along this line led to the introduction of various types of artificial driers to further reduce the moisture to the 10 to 15 per cent necessary for production of briquettes. Part air-drying was accomplished at comparatively low cost, but efforts to complete the drying by artificial heat proved uncommercial.

Another important cause of failure was the character of the product. The briquettes made from peat without the use of a binding material were hygroscopic, owing to the imprisoned air they contained, and rapidly disintegrated when exposed to moist air, and even when freshly made suffered considerable loss in transportation and handling.

The efforts were gradually abandoned after unsuccessful experiments covering a period of several years. Although the actual expenditures involved are not known, their aggregate amount must have been several hundred thousand dollars.

Among the companies promoted and organized to manufacture briquettes by employing the Dickson press were the the following:—

	Bog
Brockville Peat and Power Co., Ltd., Brockville	Brockville
Cornwall Peat Company, Cornwall	Newington
Huron District Peat Co., Stratford	Brunner
Lanark County Peat Fuel Co., Perth	Perth
Ontario Peat Fuel Co., Ltd.,	Welland
Ottawa Peat Co., Ltd., Ottawa	Mer Bleu
Peat Industries, Ltd., Toronto	Welland
Prince Edward Peat Fuel Co., Ltd., Picton	
Quebec Peat Co., Quebec	Portneuf
Simcoe Peat Fuel Co., Ltd., Barrie	
Southern Ontario Peat Co., Ltd., Brantford	
Stratford Peat Co., Ltd..Stratford	Brunner
Toronto Peat Fuel Co	Near Picton
Trent Valley Peat Fuel Co., Peterboro	Kirkfield
Western Peat Fuel Co., Chatham	Rondeau

Dobson presses were employed first by the inventor, Alex Dobson, at Beaverton; and later by the Montreal and Ottawa Peat Company, Limited, on the Alfred bog near Caledonia Springs; the Western Peat Fuel Company of Chatham, and others.

[1]Peat Fuel, its Manufacture and Uses, by W. E. H. Carter, Ont. Bureau o fMines Rept., Vol. XII, 1903.

Other briquetting companies were the Grand Valley Peat Products, Limited, formed to operate on the Luther bog; the Condensed Peat Fuel Company, Limited, of Peterboro; the Manitoba Peat Company at Fort Francis, Ontario; and the Imperial Peat Company of Guelph, which employed the White briquetting machine.

VARIOUS METHODS ATTEMPTED

At Newington, Ontario, a Brosowsky peat-digging machine operated by hand-power only, was installed[1]. Pulping was accomplished by a German machine known as the Lucht mill. The pulped peat was cut in blocks, and loaded on cars which were run into ovens for drying or carbonizing the peat, through which, by means of blowers, large quantities of air at a temperature of 350 to 550°F were forced. The consumption of heat required in the process was excessive, and the ovens failed to remove the water from the peat even by a very great expenditure of heat. The peat blocks thus exposed to high temperatures, although charred on the outside, still contained large percentages of water in the centre.

An Ottawa syndicate in 1905 erected a small plant on the Brockville bog to demonstrate the Sahlstrom process.[2,3] The peat, air-dried on the surface of the bog to 50 per cent moisture content, entered a drier and passed thence into a carbonizer. These were placed side by side and encased in brickwork, and consisted of a series of rotating cylinders through which the peat was continuously passed by means of inclined lifters attached at regular intervals along the interior of the cylinders. Entering a hopper at one end of the drier, it passed through three open-end cylinders placed one above the other, and from the far end of the bottom cylinder was elevated to the top of the carbonizer. This consisted of five rotating cylinders placed one above the other, and each enclosed in an outer stationary cylinder so arranged that the incoming and outgoing material acted as a seal permitting the gases formed to be drawn through outlets from each cylinder independently of the others. Heat was furnished by the burning of fuel in a firebox under the carbonizer. The combustion gases after passing upwards through the carbonizer were drawn into the drier where the waste heat was used for extraction of moisture from the peat. By this process the temperature of the peat treated was raised by gradual stages thereby facilitating the separate extraction of various by-products in the several cylinders. The final product, consisted of peat charcoal in powdered form or compressed into briquettes. Apparatus was installed by which a portion of the carbonized peat powder was used as fuel to run the carbonizer and drier. The objective of the process in addition to production of carbonized peat, was to obtain gas, tar, and other by-products. The extensive capital requirements for a commercial plant, and uncertainty as to disposal of by-products, in addition to technical difficulties encountered, precluded any attempt to operate on a commercial scale and led to abandonment of the experiments, without any results being reported.

[1] Peat Fuel, Its Manufacture and Uses, by W. E. H. Carter, Ont. Bureau Mines Rept., Vol. XII, 1903.
[2] Peat in Canada, by R. R. Chalmers, LL.D., Bulletin No. 880, Geological Survey of Canada.
[3] Peat and Lignite, by E. Nystrom, No. 19, Mines Branch, Dept. of Mines.

The Quebec Combustible Company, Limited, of Fraserville, Que., in 1901, operated at the Cacouna bog, pulping the peat and mixing it with crude petroleum and other combustibles, after which it was put into a moulding machine, formed into bricks and dried. The process was a mere experiment, and the plant having been burned was not rebuilt.

The Ideal Gas Company, Inc., of Montreal, proposed after partly air-drying the peat, to add crude oil and treat the mixture in retorts for production of illuminating gas and by-products.

The Peat Board Company, Limited, was formed with an authorized capital of $250,000 to operate on the Cannington bog in manufacturing peat-paper, cardboard, etc., by a patented Austrian process.

The Peat Gas and Coal Company, a Maine corporation, operating at St. Bonaventure d'Upton, Que., was stated to have "a wonderful process for treating peat through which by means of a cheap chemical solution, without drying or compressing, the peat is transformed immediately into gas material." Needless to say, this venture ended in failure.

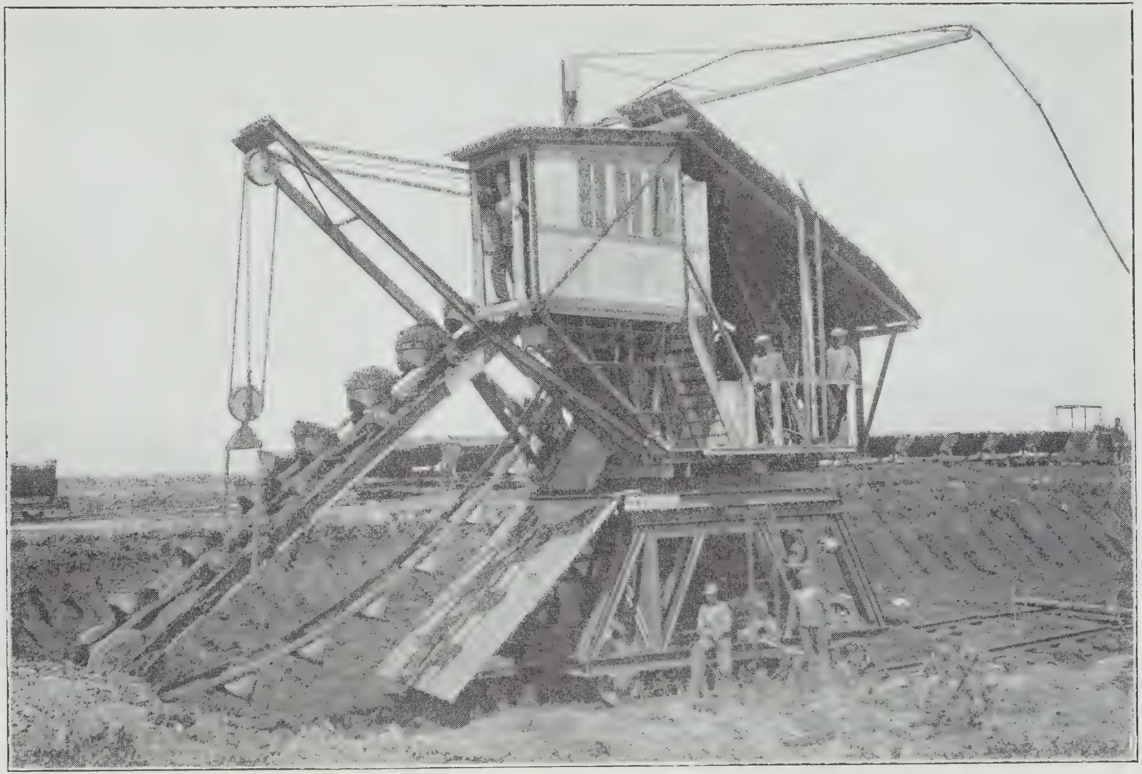
AIR-DRIED MACHINE-PEAT

About 1904 Ernest V. Moore and D. H. Moore began experimental work on the production of air-dried machine-peat at the Victoria Road bog. A few hundred tons of fuel of excellent quality was produced in the course of their operations, but the methods and machinery used were not economic, and the effort resulted in financial failure.

Several years later, in 1909 and 1910, the manufacture of air-dried machine-peat was undertaken at the plant of the Canada Fertilizer Company at Farnham, Que., by the International Peat Engineering Company, Ltd. The installation made at Farnham was notable as being the first attempt to combine the several operations of excavating, pulping, spreading, and forming the peat in a single self-contained machine, operating under its own power, and travelling over the surface of the bog supported on caterpillar aprons. The motive power supplied by a 36 h.p. gasoline engine, served to operate an excavator of the chain and bucket type, the conveyer for delivering the excavated peat to the macerator, an Anrep macerator of the largest size, and devices for spreading the pulped peat and cutting it into blocks of the desired size, which in this particular installation was about 5 by 5 by 10 inches, before drying.

The bog was laid out as nearly as possible in rectangular form divided by lines 100 feet apart. In operation the machine moved along one of these lines, excavating a ditch along it of the depth required to fill the spreading-box, the peat excavated being spread behind the machine as it advanced and parallel with the ditch. When the ditch had been dug the full length of the first line, the machine turned squarely around under its own power, and returning made a second cut doubling the width of the ditch and spreading the dug material on the other side of it. The machine then travelled to the next line 100 feet away and repeated the operation, proceeding in similar manner from one line to another until the peat laid along the first ditch was air-dried and removed from the field.

Apart from the small capacity of the machine there were a number of serious objections to the method of excavation and spreading employed.



Ekelund-von Porat excavator

Small Anrep peat machine

(1) By the method of excavation the bog would be cut into a series of narrow longitudinal strips separated by ditches. As work proceeded the width of these strips would grow less until they were finally too narrow for the machine to operate.

(2) The depth of excavation, which was controlled by the width of the narrow spreading-area along each cut, was necessarily very shallow, not more than three or four feet. The underlying portion of the bog after removal of the natural surface would be left in a state unfit to be worked by any machine travelling on the top of the bog. For this reason, and because of the longitudinal strips which would necessarily be left altogether unexcavated, only a very small portion of the peat in a bog could be recovered by such a machine, and the bog at the same time would be left in a very unfavourable condition for excavation by any other method.

(3) The necessity for frequent moves from one part of the field to another would cause serious loss of time and thus reduce the capacity of the machine.

(4) The disposal of the spread peat on the drying-area in long narrow strips divided by ditches would render harvesting operations expensive.

A Dominion charter was obtained for a company known as Peat Industries, Limited, to carry on the Farnham operations, but after very considerable expenditures had been made, the project was abandoned with financial loss.

GOVERNMENT PLANT AT ALFRED

Following the many failures in Canada of attempts to manufacture peat briquettes, and to utilize other processes employing artificial heat and mechanical pressure to separate the moisture from peat, a widely-signed petition was presented to Hon. Frank Oliver, Minister of the Interior, in 1906, requesting that an investigation be undertaken by the Mines Branch to obtain reliable information that would aid in development of the peat resources of Canada, especially in the provinces of Ontario and Quebec. This petition was afterwards referred to Hon. William Templeman, Minister of Mines, for action, and in 1907 Erik Nystrom—an engineer on the staff of the Mines Branch—was appointed to investigate the peat industry in Europe, and his report upon methods, processes and machinery employed in the commercial production of fuel from peat was published in the following year.

The investigation showed that the only method which had been successfully employed in Europe for the production of fuel from peat, was the air-drying method, the product of which is air-dried machine-peat.

The Director of Mines, Dr. Eugene Haanel, then inaugurated a general policy to promote the development of a peat industry in Canada which proceeded along the following lines.

(1) Erection of a small plant to demonstrate methods of manufacture and machines which had achieved the greatest commercial success in Europe at that time.

(2) Establishment at Ottawa of a fuel testing station for the carrying on of investigations relating to Canadian fuels generally, and especially to study means of economical utilization of peat and other low-grade fuels of which Canada possesses enormous supplies.

(3) The survey of the more readily accessible peat bogs and determination of the quantity, character, and calorific value of the peat contained in them, with such other particulars as might be of value in facilitating their utilization as a source of fuel.

In this way it was sought to lay foundations on which the structure of a commercial industry might later be erected. The demonstration plant was in no sense intended as a commercial installation, but was merely to serve as an illustration of the stage in manufacture of peat fuel which had been reached in Europe, and as a basis for development of machines and methods which would be suitable for employment under Canadian conditions.

In the summary report of the Mines Branch for 1908 it was stated that:—

> The introduction of a fuel like peat is, however, an undertaking that cannot be expected to be accomplished in a year or two, but will require a long and aggressive educational campaign, in order to demonstrate the value of the products, as well as the manner of manufacture.
>
> Drying conditions in Canada are at least as good—if not better than in most European countries. And notwithstanding the higher rate of wages in Canada, a properly managed peat plant should give satisfactory economical results.

An area of 300 acres, a portion of the Alfred bog, in the county of Prescott, Ont., about forty miles from Ottawa, was purchased, cleared, drained, the necessary buildings erected, and a railway siding installed.

Peat-manufacturing machinery of the types that had been found most satisfactory in European practice, was imported and installed at the bog, the equipment consisting of an Anrep peat machine with conveyer (Plate X) having a production capacity of 25 to 30 tons of air-dried peat fuel per day, and a Jakobson field-press (Plate XI) together with a 35 h.p. steam boiler and engine to supply motive power, a number of steel dumping cars, 1,200 feet of light, portable track for transporting cars to the field-press, and about half a mile of light, narrow gauge field track.

The Anrep machine comprised an elevator for raising the hand-excavated raw peat from the bog, a conveyer, and a macerator for pulping the wet peat, all carried on a platform supported on wheels running on rails laid on the surface of the bog in advance of the movement of the machine. This apparatus is described in E. Nystrom's report.[1]

Manufacture of fuel was carried on for about two months in 1910 (50 working days) and throughout the summer of 1911 (93 working days) the total output being about 3,000 tons, of which over 1,600 tons were distributed for domestic use, principally in Ottawa.

The fuel was sold at a nominal price in small lots to a large number of customers for trial. A questionnaire issued by the Canadian Peat Society, asking for the experience and opinions of users, elicited over 150 replies which evidenced practically a unanimity of favourable opinion.

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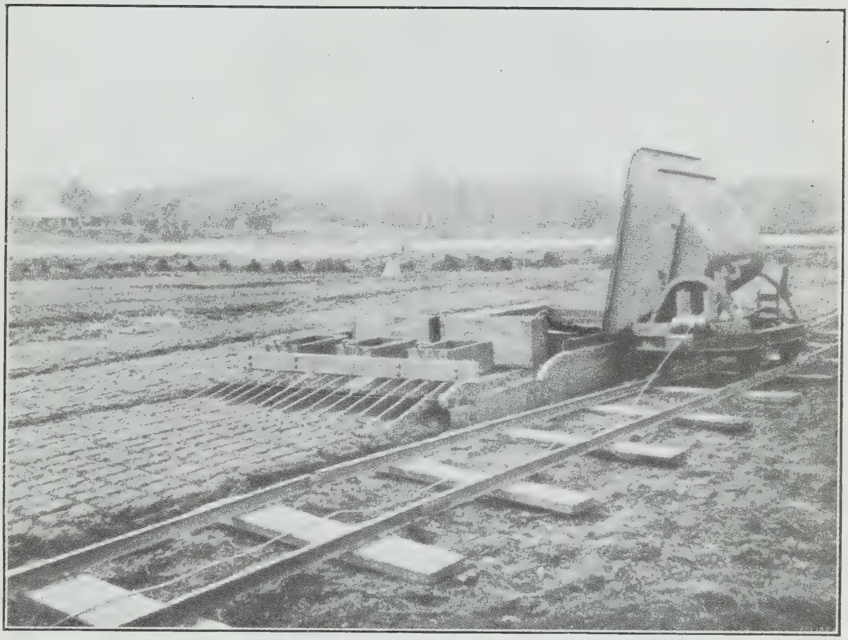
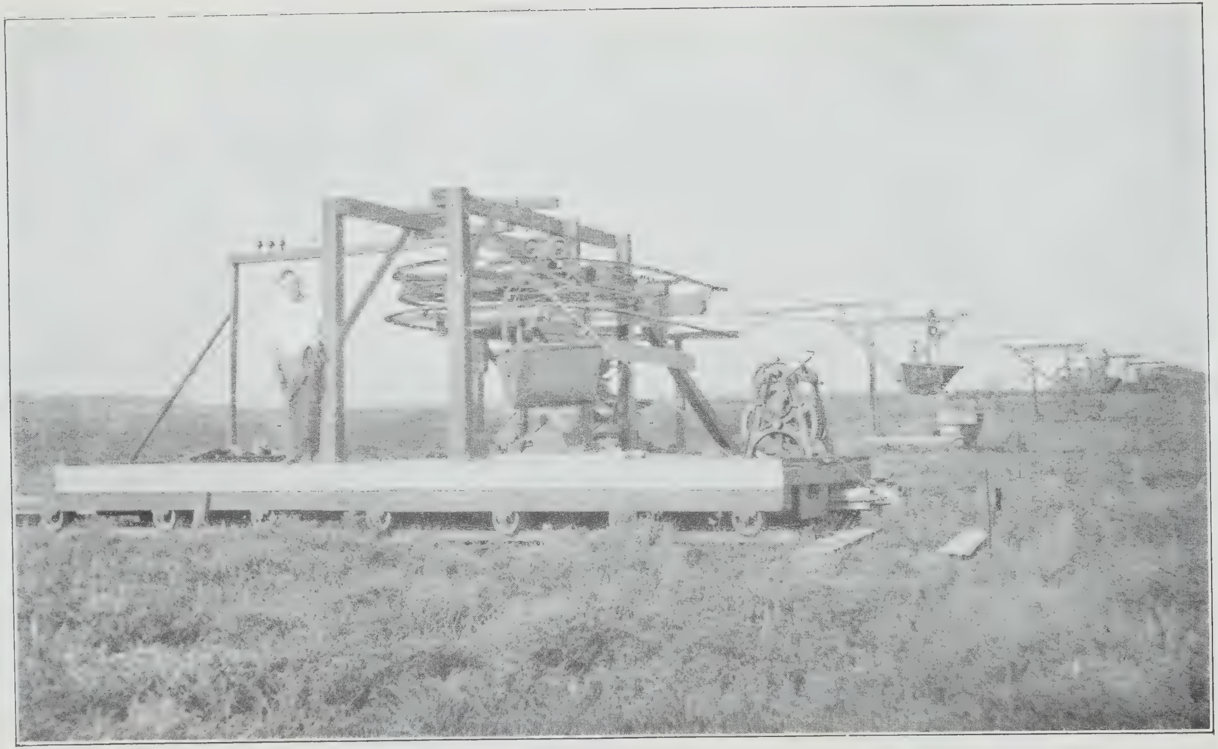
[1] Peat and Lignite, by Erik Nystrom, No. 19, Mines Branch, Dept. of Mines, Canada.



Jakobson field-press and spreader



E. V. Moore's aerial cableway and conveyer

Excavation of the peat at this plant was done by hand, men in the trench shovelling the raw peat into the inclined elevator, which delivered it to the machine. Labour requirements for the operation of the plant and the scale of wages paid were:—

1 engineer, per day	$ 2 50
7 men in trench, excavating peat at $1.75 per day	12 25
3 men on field-press at $1.75 per day	5 25
1 man filling cars at $1.75 per day	1 75
4 boys at $0.75 per day	3 00
1 extra man	1 75
Total daily wages	$ 26 50

As a result of the investigation made in Europe, the subsequent operation of the plant at Alfred, and experimental work carried on at the Fuel Testing Station in the use of peat fuel in gas producers for power purposes, the conclusions arrived at by the Department in 1911 were:—

(1) That the air-dried machine-peat process is the cheapest and most practical method of manufacture.

(2) That by utilizing mechanical excavators, and manufacturing on a commercial scale, peat fuel for local use, or for use within reasonable distance of a bog, can successfully compete with anthracite coal.

(3) That for power purposes peat is a most admirable fuel and, as compared with bituminous coal, can be used with greater economy in the gas producer, assuming $2.00 per ton as cost of peat, and $4.00 per ton that of bituminous coal.

ANREP-MOORE PLANT BUILT BY J. M. SHUTTLEWORTH

In the fall of 1911 operation of the government plant was discontinued and Mr. J. M. Shuttleworth, Brantford, undertook to install at Alfred a plant employing a mechanical excavator to take the place of hand-digging, substituting a cableway conveyer for the dumping cars heretofore used, and introducing other improvements in the method of handling the peat, with a view to reduction of the high labour cost involved.

The plant was erected during the summer of 1912. The excavator, designed by the late Aleph Anrep of Helsingborg, Sweden, was substantially, though not in details, the same as that employed in Plant No. 1 built by the Peat Committee and described later in this report. According to practice then prevailing it was carried on wheels resting on rails laid in advance of the machine on the surface of the bog. An Anrep macerator of standard type and of the largest size made was used.

A distinctive and novel feature of the plant, designed by E. V. Moore, engineer in charge of construction, was the transportation of the peat pulp to the drying-field by means of an aerial cableway carrying buckets which were automatically tipped on arrival at the spreader. The following is a short description of the system.[1] (Plate XII.)

The cableway consisted essentially of two opposed towers, about 900 feet apart, supported on wheels resting on rails held in place by ties of special construction. These permitted the movement of the towers in a direction at right angles to a line drawn from one tower to the other, the

[1] Peat, Lignite and Coal, by B. F. Haanel, No. 299, Mines Branch, Dept. of Mines, Can.

distance between the towers remaining the same. Two parallel cables, lying in the same horizontal plane, were strung between the two towers. At each end, means were provided for putting any strain desired on the cables, which were attached to two rigid semi-circular tracks connected to the tower. These tracks were attached to the cables in such a manner that a continuous and endless single track was obtained in the form of a horizontal loop about 900 feet long, 9 feet wide, and about 8 feet 6 inches above the surface of the bog.

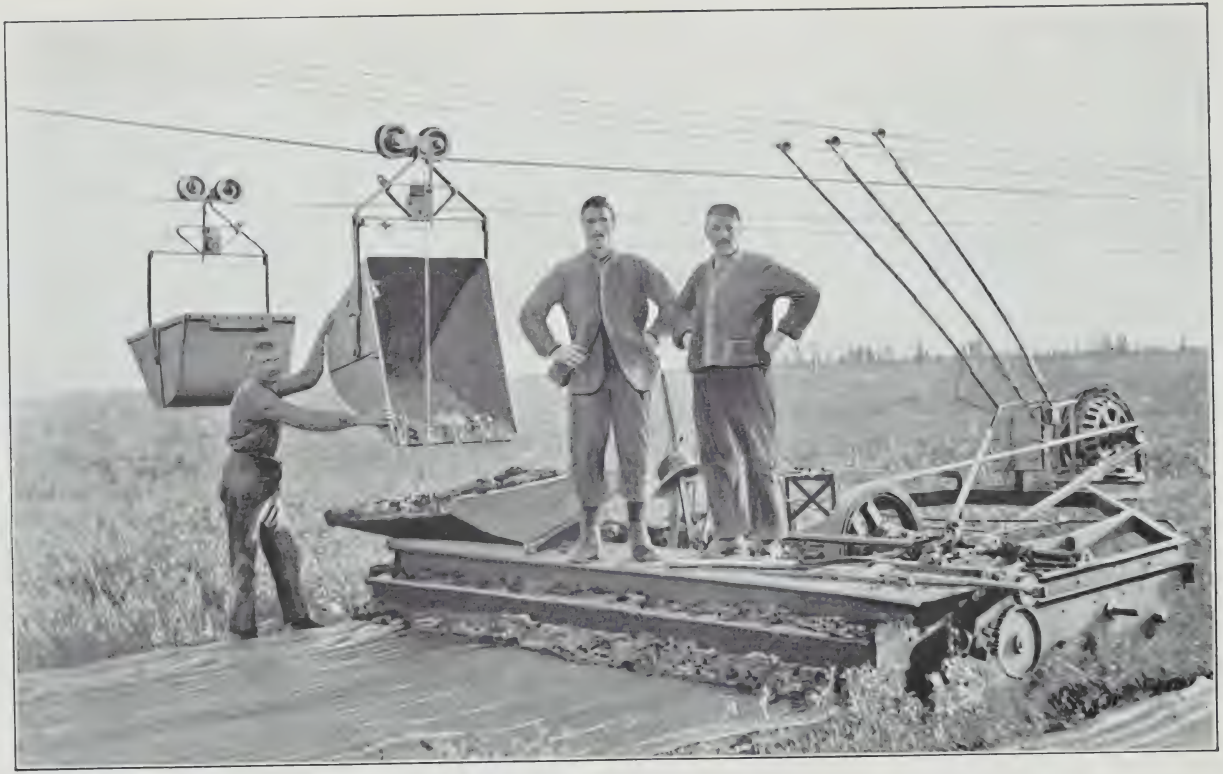
Light wooden supports were placed at intervals of 75 feet between the two main towers. These were supported on wheels which permitted their movement only in a direction parallel to that of the end or main towers. The cableway was attached to these intermediate supports by means of cable saddles, and was in this manner kept parallel, and at the proper distance from the surface of the bog.

Twenty-four steel buckets, each of 10 cubic feet capacity, were provided for carrying the peat. These buckets were slung in a bail which, by the loosening of a catch, permitted them to be dumped. A two-wheeled truck, to which the bail was attached by means of a flexible joint, served to support the buckets. The haulage cable was endless, and received its motion from a series of drums and pulleys situated on the tower nearest the excavator. The 10 h.p. motor which drove the haulage cable was placed on this tower. The haulage cable ran from the drums and pulleys of the inside tower parallel to and under the track cable to the outside tower. At the tower it passed around a large cable sheave, which supported and directed it in such a manner that it kept directly below the semi-circular track. The cable then returned to the first tower parallel to, and underneath the cable track, on which the emptied buckets were returning to the loading hopper.

The buckets were clutched to the haulage cable at intervals of not less than 75 feet, so that it was impossible for two loaded buckets to get between any two consecutive cable supports at the same time.

The clutches were so designed that they automatically picked up and engaged the haulage cable as the buckets were pushed out, when filled, from the loading hopper. When it was desired to dump the bucket, the clutch could be made to disengage the cable conveniently, and in such a manner that the cable passed through the clutch without coming out. When the bucket had been dumped, a slight movement of the clutch lever served to engage the clutch with the cable. When the empty bucket arrived at the loading end of the cableway, it was automatically released from the cable, which passed over a guide pulley to the drum which imparted the motion. The bucket then continued its journey for a short distance until it was in a position convenient to the loading hopper.

When the cableway was in operation, a sufficient stress had to be put on the track cables to prevent a deflection greater than twenty-four inches, when the loaded bucket—about 1,000 pounds in all—was in the centre of a span. This meant a stress of many tons tending to pull the two main towers together. The towers, if made sufficiently heavy to resist this pull, would be too cumbersome to move conveniently, hence they were attached to the ties, which in turn were anchored to the bog. The towers were attached to the ties so that they could be moved when desired without altering the stress on the cables.



Moore spreader

For the Jakobson field-press there was substituted a spreading-device also designed by E. V. Moore and shown in Plate XIII, which may be briefly described as follows:—

The peat to be spread was dumped into an oblong box about 12 feet in length, which was drawn sideways over the surface of the bog by means of a small caterpillar tractor to which it was flexibly attached. It was evenly distributed in the box along its entire length by a screw conveyer and was discharged through 34 moulding-spouts, each 4 by 4 inches, slightly rounded at the corners, placed side by side along the bottom of the box. The peat was forced through these spouts separately by a small screw placed in each, the operation of which could be so regulated that the peat could be delivered from the spouts at any desired rate. The peat issued from the spouts directly on the surface of the bog in moulded ribbons forming a row about 11½ feet wide. These were automatically crosscut by a special attachment fastened to the rear of the spreader.

The spreader with all its moving parts, when loaded, weighed about 3,000 pounds, and, as it was moved over the drying-field, all small inequalities in the surface of the bog were smoothed down.

In operation the spreader advanced at an average speed of 7 feet per minute and at this rate of travel could spread on the drying-ground 26½ cubic feet of raw peat per minute. Its capacity for continuous operation was therefore about 8·4 tons per hour of 25 per cent moisture fuel, when the raw peat contained 87½ per cent moisture. Electric power for operation was transmitted by trolley wires, strung directly overhead, to a motor placed on the machine.

The entire plant was electrically operated by current supplied from a steam plant located in a central power house built on solid ground near the bog. With the plant in full operation, the switchboard showed a maximum of 20 amperes at 2,200 volts or nearly 60 h.p. Air-dried peat fuel was fired under the boilers, the quantity required being less than 2½ tons per 10 hours.

Although the installation embodied very promising features, the stage of commercial production was not reached. It was anticipated that necessary alterations would be completed, and the plant would be in full running order for the season of 1913. Owing to the withdrawal of Mr. Shuttleworth, who left to reside in England, funds for carrying on work were not available, and it was not until 1914 that financial arrangements to permit active operation were completed. The Canadian Peat Company, which had been formed meantime, operated the plant for a portion of the season, but the outbreak of war led to withdrawal of financial support and the plant was permanently closed down early in August 1914.

CHAPTER V

DEHYDRATION OF PEAT—PROCESSES AND METHODS DEVISED

DRYING BY APPLICATION OF ARTIFICIAL HEAT

The applicability of any process for drying peat by the employment of artificial heat is limited by two important factors, viz.:—

(1) The amount of heat required.

(2) The cost of the operation.

The artificial drying of peat is not a process which simply involves the evaporation of so many pounds of water. Peat has peculiar physical properties that make the solution of the problem difficult, one of the most important of which is its poor conductivity of heat. When wet peat is subjected to a comparatively high temperature, as in a drying-oven heated directly by the combustion of some fuel, the surface may become charred before even a small percentage of its moisture has been expelled. Pieces of peat dried in this manner have on inspection been found to be completely charred on the outside although the moisture content on the inside was still nearly 76 per cent. Although a thermal efficiency of 70 per cent is quite possible in the evaporation of water from many substances, it cannot be realized in practice in the drying of a substance with such poor heat conductivity as peat. A drying plant in actual operation in connexion with the Mond peat power gas and by-product recovery plant at Orentano, Italy, showed a thermal efficiency of only 52 per cent.[1]

Since high temperature gradients must be maintained for rapid drying, the peat will have lost an appreciable amount of volatile matter before the drying is completed. Furthermore, the natural cohesive properties of the peat will have been destroyed, and it must be submitted to further expensive treatment to render it in a form fit for fuel.

All types of artificial driers for the removal of moisture from peat utilize heat from the combustion of fuel. A process which has for its object the production of fuel becomes uneconomic when too large a proportion of the product or its equivalent must be consumed in the operation of manufacture.

The amount of heat required to reduce the water content of raw peat sufficiently to produce a serviceable fuel is so great as to render any process depending upon artificial drying wholly impracticable.

When the peat to be dried contains moisture above a certain percentage, the evaporation of the moisture by means of the combustible matter contained in the peat or its equivalent becomes impossible. The illustrative curves (Figure 7) were constructed to show when the process of drying with heat produced by the combustion of peat containing varying percentages of moisture becomes impossible. These curves show the quantities of dry, 20, 25, 35, and 45 per cent moisture peat it is necessary to burn in order to obtain 100 pounds of peat, dry and of 20, 25, 35, and 45 per cent moisture. The calorific value of absolutely dry peat is assumed

[1] Peat, Lignite and Coal, by B. F. Haanel, No. 299, Mines Branch, Dept. of Mines.

for these calculations to be 9,500 B.T.U., while the lower calorific value of the peat, when containing 20, 25, 35 and 45 per cent moisture, is calculated on the assumption that a quantity of heat is required to raise the temperature of the contained water from 62°F. to 212°F., and to evaporate it, i.e., the calorific value of peat containing X per cent of moisture is (9,500-106X) B.T.U. The quantity of heat required to evaporate one pound of contained moisture is taken as 1,120 B.T.U., and the efficiency of the process of evaporation is taken as 70 per cent.

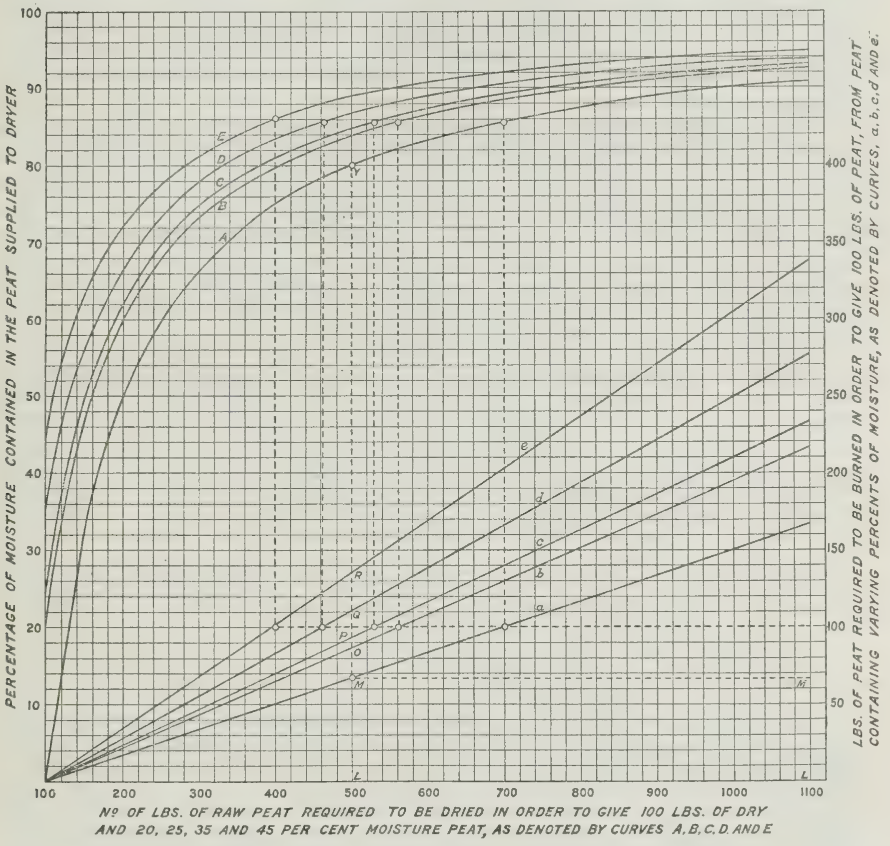


Figure 7

The curves A, B, C, D, and E, show the quantities of raw peat of any moisture content which require to be supplied to the drier, in order to produce 100 pounds of dry peat, (A); and peat of the following moisture contents: 20 per cent (B), 25 per cent (C), 35 per cent (D), and 45 per cent (E). The curves a, b, c, d, and e, show the quantities of peat, dry and containing 20, 25, 35, and 45 per cent moisture it is necessary to burn in order to evaporate sufficient moisture to produce dry peat, or peat containing 20, 25, 35, and 45 per cent moisture, from peat of any moisture content.

For example, if it is desired to produce 100 pounds of dry peat substance from raw peat containing 80 per cent water, the line Y-L dropped from the point Y, corresponding to 80 per cent moisture, on the curve A, to the abscissa shows that 500 pounds of peat containing 80 per cent moisture are required to produce 100 pounds of dry peat. The curve A shows the number of pounds of raw peat required to produce 100 pounds of dry peat. The intersection of the line Y-L with the curve a at M shows the number of pounds of dry peat—the intersection of M-M with the right hand ordinate—it is necessary to burn in order to evaporate the moisture from 500 pounds of raw peat containing 80 per cent moisture, in order to produce 100 pounds of dry peat substance. For this particular case, it will be seen that 67 pounds of dry peat substance must be burned to produce the required heat.

The quantity of peat containing 20, 25, 35, and 45 per cent moisture it is necessary to burn in order to produce 100 pounds of dry peat substance from peat containing 80 per cent moisture, can be determined in like manner by drawing horizontal lines from the intersections O, P, Q, and R of the line L-Y with the curves a, b, c, d, and e, and reading the number of pounds required directly on the right hand ordinate. The number of pounds of peat which must be burned in order to produce 100 pounds of peat containing 25, 35, etc., per cent of moisture, can be determined in a similar manner from the curves B, C, D, and E.

From these curves it will be seen that in order to produce 100 pounds of dry peat, or 100 pounds of peat containing 20, 25, 35, and 45 per cent of water from peat containing 86 per cent of water, 100 pounds of peat dry, of 20, 25, 35, and 45 per cent moisture must be burned. Hence the limiting value of the process is 86 per cent—the absurdity, therefore, of attempting to dry peat of this moisture content by means of artificial heat is apparent.

Artificial drying may be accomplished by:—

1. Hot air heated by direct combustion of fuel or by exhaust steam, etc.
2. Hot products of combustion of fuel or gases from the exhaust of gas engines, etc., mixed with air.
3. Forced circulation of atmospheric air.
4. Various combinations of these.

It is apparent from the curves shown above that the production of the required heat by the direct combustion of a fuel will always prove too expensive.

Where waste gases and waste heat from independent industrial operations are available in sufficient quantities, these might be employed to remove the excess moisture from peat with some measure of success. But the waste gases and waste heat produced in any economic process for the manufacture of peat would never be sufficient, even if all utilized, to provide for more than a small portion of the heat requirements for drying.

In the Mond gas plant at Orentano,[1] in which the objectives were the recovery of sulphate of ammonia and other by-products and the production of gas for power purposes from peat, the waste heat from the boiler plant and exhaust gases from two gas engines of 300 brake horsepower each, were utilized to aid in drying the peat from 77 to 30 per cent. For the production of

[1] Peat, Lignite and Coal, by B. F. Haanel, No. 299, Mines Branch, Dept. of Mines.

20 tons of 30 per cent moisture peat per day, it was found necessary to supplement the waste heat available by burning gas to produce heat equivalent to that produced by the combustion of 8 tons of 30 per cent moisture peat per day in a specially constructed furnace for heating air. Thus approximately 25 per cent of the heat required for drying was obtained from the exhaust of the two gas engines, 15 per cent from the waste heat from the boiler plant, and the remainder, amounting to 60 per cent of the entire heat requirements, had to be supplied by the direct combustion of fuel.

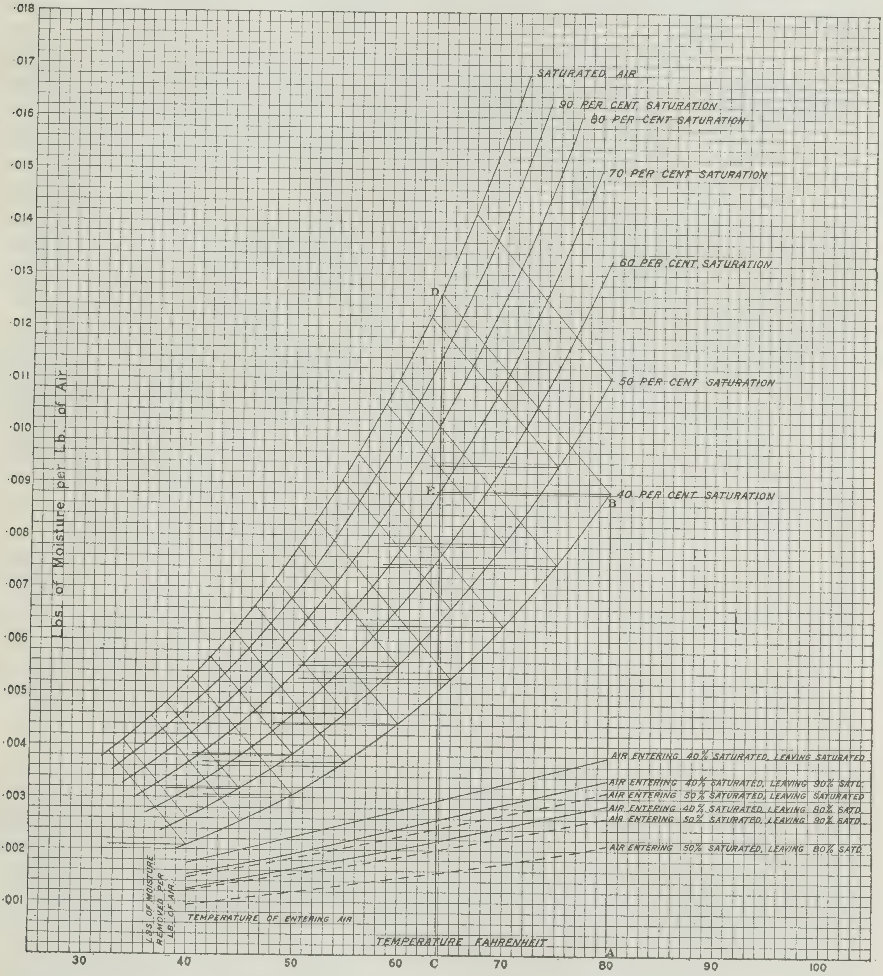


FIGURE 8. Curves showing the pounds of moisture per pound of air for varying degrees of saturation and temperature

There remains to be considered the drying of peat by forced circulation of atmospheric air.

ARTIFICIAL DRYING OF PEAT BY AIR

When unsaturated air is passed over water it becomes more nearly saturated with moisture. In so doing its temperature is reduced. For any degree of saturation of the entering air the fall of temperature in passing over the water will depend upon the degree of saturation of the discharged air. The amount of water removed by the air will depend upon the reduction of temperature of the air as it takes up moisture until it reaches any definite humidity.

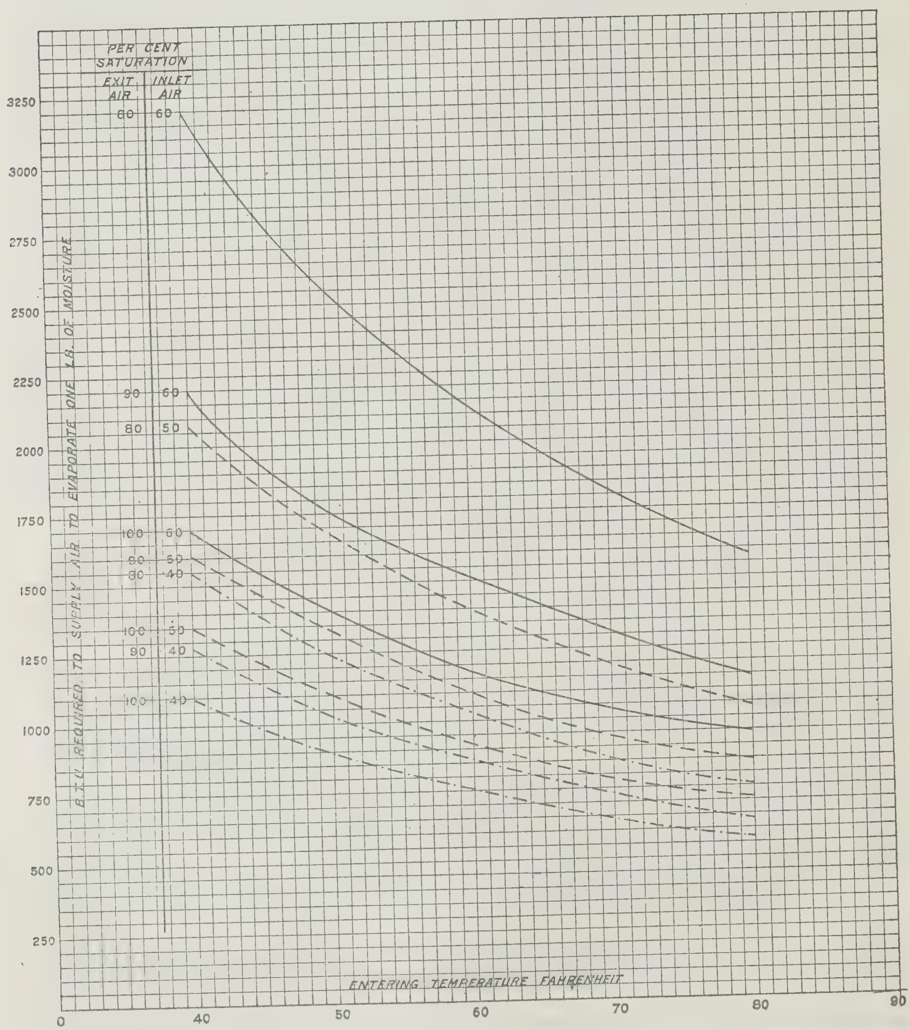


FIGURE 9. Curves showing the number of heat units in the peat, that would be requred to drive over the moisture

A series of curves (Figure 8) has been prepared showing the pounds of moisture present per pound of air for varying degrees of saturation and temperature. The inclined lines in these curves are drawn to show the increase in the quantity of vapour per pound of air when the temperature of the air is reduced by passing it over water which is supposed to remain at the constant temperature of 60°F. Thus the ordinate A B represents the pounds of vapour per pound of air for 40 per cent saturation and a temperature of 80°F. If this air be passed over water it will become saturated at 63·7°F. when the moisture content will be represented by the ordinate C D. The difference between the ordinates C D and A B or E D will then represent the amount of moisture removed per pound of air. Similarly, from the curves the amount of moisture removed with an increase to 90, 80, 70, 60 or 50 per cent saturation may be found.

The curves have been constructed for air entering at 40 and 50 per cent saturation.

The lower set of curves show the pounds of moisture removed per pound of air entering with 40 and 50 per cent saturation and varying temperatures and leaving saturated or 90 per cent or 80 per cent saturated.

From these curves the pounds of air required to evaporate one pound of moisture may be calculated. In the case of any proposed installation for the drying of peat by this method, it is necessary to estimate the number of heat units in the peat which would be required to drive the air over the moist substance. These figures have been calculated and the results are represented by the curves in Figure 9. For these calculations the following arbitrary figures are used:—

Efficiency of peat gas producer and gas engine	·125
Efficiency of electric generator	·88
Efficiency of electric fan motor	·88
Efficiency of fan	·66

giving an overall efficiency of ·0639.

The pressure at which the air is delivered by the fan is assumed as $1\frac{1}{2}$ inches of water above the atmosphere.

The heat in the peat necessary to propel one cubic foot of air at a pressure of $1\frac{1}{2}$ inches of water (or 7·8 pounds per square foot), will be

$$\frac{7{\cdot}8}{778} \times \frac{1}{{\cdot}0639} = 0{\cdot}157 \text{ B.T.U.}$$

It will be observed that the lowest figure shown on the curves is that for air entering with 40 per cent humidity at 80°F and leaving saturated, this figure is as low as 570 B.T.U., but it is extremely unlikely that so low a figure would be reached in practice, the inlet air temperature being higher and the humidity lower than might be expected, moreover, the practicable size of the drying-chamber would preclude the complete saturation of the air.

A general examination of the curves will show that with ordinary conditions throughout a season, little, if any, better results might be expected by artificial air-drying than by the direct heating method. The limits of such a method as the latter have been previously demonstrated.

Apart from a reduction in the quantity of manufactured fuel due to the heat requirements of any process employing artificial drying, other factors have a very important bearing in determining the economic possibilities of such a process. Only the principal of these need be considered here:

First: Peat is a low-grade fuel as compared with coal, consequently the cost of manufacture must be kept within very low limits.

Second: Very large quantities of raw material must be dealt with, in proportion to the heating value obtained in the final product. Since about $7\frac{1}{2}$ tons of raw peat of 90 per cent moisture content must be excavated in order to produce one ton of peat with a 25 per cent moisture content the cost of transportation of the raw material to a central plant, and of handling same to and from the driers becomes an important cost factor in the process.

Third: The large quantity of raw material required for a comparatively very small production of finished fuel necessitates driers and other apparatus of inordinately large capacity as compared with those required for the handling of other fuels, and this increases to a serious extent the necessary capital outlay.

Many driers have been devised for evaporating the moisture from peat, for which high efficiencies have been claimed, but none of these have so far proved economic.

After a general survey of the European peat industry, past and present, Hausding has arrived at the following conclusions in respect to artificial drying of peat, viz.: "that every artificial drying plant no matter how promising it seemed to be has up to the present always proved too expensive, both as regards plant costs and running expenses; that the heat, or other energy corresponding to it, required to evaporate the amount of water is so great that from the commercial standpoint complete failure must be inevitable, even when the technical contrivances are assumed to be as perfect as possible; and that whoever values his money should never attempt the artificial drying of peat".[1]

Experience in the United States goes to confirm these views. Charles A. Davis, late peat expert to the United States Bureau of Mines, in his work on the Uses of Peat[2] stated that any plan to be successfully incorporated in machinery for completely freeing freshly dug peat from its high percentage of water, must provide for utilization of large quantities of waste heat or of fuel that has no other economic uses. Soper and Osbon[3] say that the failure of many peat plants in the United States has been due to improper choice of manufacturing processes and machinery. The excess moisture in the peat must be eliminated at as early a stage as possible in the manufacturing process. This drying can be most economically done by evaporation on the surface of the deposit.

The general situation as regards artificial drying of peat at the present time is thus summed up in the report of the British Fuel Research Board.[4]

> No economic method of drying by artificially generated heat is yet available, and in every case where peat is used commercially at the present time, the peat has been air-dried.
>
> Attempts have been made, and are still being made in every country in which peat exists, to dry the peat by the application of heat in different ways. Methods involving pressure and combinations of heat and pressure have also had extensive trials. But the fact remains that although experimental success has frequently been claimed, there is no process based on the application of pressure, or heat and pressure, producing peat and working on a commercial basis today.

[1] Handbook on the Winning and the Utilization of Peat, by A. Hausding.

[2] The Uses of Peat for Fuel and Other Purposes, by Charles A. Davis, U.S. Bureau of Mines, Bulletin No. 16, 1911.

[3] The Occurrence and Uses of Peat in the United States, by E. K. Soper and C. C. Osbon, U.S. Geol. Surv. Bull. No. 728, 1922.

[4] The Production of Air-dried Peat, Report of the British Fuel Research Board for the years 1922-1923.

DEHYDRATION BY MECHANICAL PRESSURE

The idea that the process of manufacture of fuel from raw peat could be greatly hastened by the expulsion of a large proportion of the contained water by mechanical pressure has been widely popular and has led to thousands of experimental efforts and to the establishment of numerous large-scale plants relying upon such means to avoid the delays incidental to air-drying. Although apparently promising results have been obtained in laboratory experiments, no success in commercial production has been achieved.

Every form of press has been tried—rollers, filter presses, hydraulic piston presses of various types; and pressure has been applied in every conceivable way—low pressures gradually increasing, intermittent pressures, and extremely high pressures continued for short or long periods of time.

The net result of all such efforts has been to demonstrate that the water content of raw peat cannot be economically reduced by pressure alone to less than 75 per cent, and that the application of pressure in any form whatever to further reduce the water content requires so long a time, and the use of so much power that the process cannot be commercially employed.

Among the most recently reported experiments along this line were those conducted by Prof. J. W. Hinchley[1] in 1922 at the works of Armstrong Whitworth Co. The press employed was designed, after several years of experiment, as a small portion of a larger commercial press of six chambers to take a charge of $1\frac{1}{2}$ tons per operation. Using a pressure up to nearly 800 pounds per square inch and pressing under the very best conditions the percentage of water in peat which had been subjected to a preliminary pressing to lower its water content to 80 per cent, was only further reduced to an average of about 75 per cent. After pressing, the filtering-surfaces of the press were completely choked, and a considerable amount of work in cleaning was necessary before the press could be used again.

Elaborate experiments in pressing water out of peat were carried on for a period of several years at Dusseldorf, Germany.[2] Ample capital was available, and large expenditures were made, every idea which appeared feasible receiving thorough trial. It was claimed that the water content of raw peat could be reduced to as low as 50 per cent, but it proved extremely difficult to lower it to even 66 per cent, and this required so long a time that the process was impracticable.

The most notable effort in this direction in Canada was made at the Kirkfield bog in 1900-1 by the Trent Valley Peat Fuel Company.[3] Hydraulic presses were employed which had been specially built for the purpose and were reported to have been capable of exerting a pressure of 2 tons per square inch. The cost of operation was entirely out of proportion to the small amount of peat handled and the low extraction of water obtained, and the undertaking was abandoned.

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[1]The De-watering of Peat by Pressure, by Prof. J. W. Hinchley, Wh.Sc., A.R.S.M., F.I.C. Transactions Society of Chemical Industry, Vol. XLI, No. 24, p. 365.
[2] Handbook on the Winning and the Utilization of Peat, by A. Hausding.
[3] Peat Fuel, its Manufacture and Uses, by W. E. H. Carter, Ont. Bureau Mines Rept., Vol. XII, 1903.

A series of experiments in dewatering raw peat by pressure were conducted at Munich, Bavaria, in 1920, by Dipl. Ing. Hans F. Gross for the Bavarian Government.[1] The peat used in these tests was from both low and high bogs, and included peat easy to dewater, that which was somewhat more difficult, and well-humified peat from a transition bog. When a characteristic peat of the latter type containing 90·7 per cent water was submitted for 5 minutes to a pressure of 2,400 pounds per square inch the water content was reduced only to 81 per cent. Results of the tests are shown in the following table.

TABLE XII

Percentage of Water Contained in Raw Peat after being Subjected for 5 min. to Pressure of:

Atmospheres Lb. per sq. in.		12 180	20 300	30 450	67 1005	100 1500	160 2400
1—Haspelmmor	90·8	85·1	83·2	81·8	80·5	78·6	76·0
2—Brucker Moos	88·6	83·5	81·9	79·2	77·2	75·8	74·9
3—Schonramerfilze	89·3	84·8	83·6	80·8	79·2	77·8	76·8
4—Hochrunsfilze	89·8	86·5	84·9	82·8	80·8	79·6	78·1
5—Sanimoor	89·5	87·1	85·8	83·5	81·6	80·0	78·0
6—Konigsdorferfilze	88·7	86·5	85·3	82·8	80·9	79·7	78·6
7—Susser Flecken	90·7	87·9	87·6	86·6	83·9	82·8	81·0

The mistaken idea was long widely prevalent that the water in peat is contained in the cells still existing in the plant remains of which the peat is composed, and that by breaking down the cellular structure the removal of water would be facilitated.

Generally, very few cells exist in peat from low bogs, the contents consisting largely of the sheaths of rhizomes, roots and root cells, which under pressure retain scarcely any water, but on the contrary form channels which render the extraction of water easier. In high bogs the remains of peat moss, principally sphagnum, predominate. The structure of peat moss is such that distributed among the living cells containing protoplasm are very much larger porous cells, which serve to conduct water through the plant. Owing to its structure the plant possesses an enormous surface development, the moistening of which requires very large amounts of water. The porous, water-conducting cells, which form the greater part of the plant, can be largely dried out by pressing, and wherever they remain intact in the raw peat they form channels in the compressed cake which assist in leading the water to the surface. Contrary to common opinion, therefore, the cell structure promotes instead of hindering mechanical dehydration, and the proposal to increase the effectiveness of pressure in dewatering peat by breaking down the cellular structure is an absurdity.

The great difficulty which is experienced in removing the water content of peat by mechanical means is due to the colloidal character of the peat humus that it contains.

[1] Das Madruckverfahren für Maschinellen Entwässerung von Rohtorf. Richard Pflaum, München.

Those substances known as colloids are distinguished by the extremely minute subdivision of the particles of which they are composed, and, therefore, in contact with liquids or gases, present an exceptionally large surface of contact in relation to their mass. Not only the contents of the cells in peat-forming plants, but also the structureless materials produced by humification or decomposition of the organized structure are colloids. These products of humification, which may be designated peat humus, resemble in certain respects such substances as glue, gelatin, starch paste, and soap. Peat humus has in common with them the property of absorbing very large quantities of water, and of shrinking very greatly in drying.

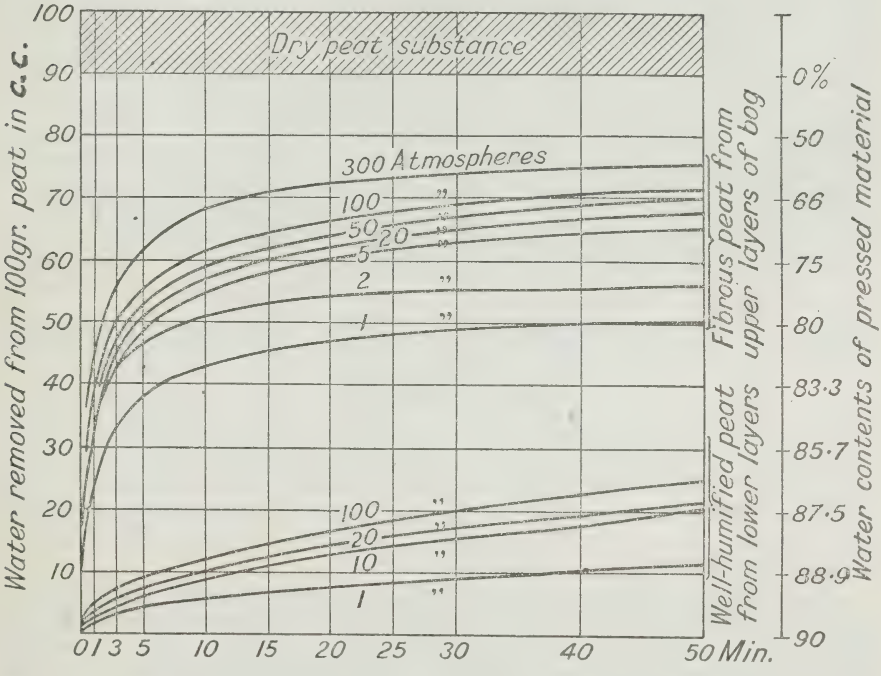


FIGURE 10. Curves showing results obtained in dehydrating fibrous young peat, and older well-humified peat by subjecting them to pressure for varying lengths of time

Water is held in colloids in such a manner as to render its expulsion by mechanical pressure a physical impossibility, since the particles of which they are composed are so minute and have so strong an attraction for the molecules of water, that the pressure exerted to expel the molecules of water will also carry off the particles associated with them. In direct proportion, therefore, to the degree of humification of peat and the amount of colloidal matter it contains, which for practical purposes means in proportion to its value as a source of fuel, the amount of the contained water which can be removed by pressure decreases.

From this it follows that young or new peat in which the cellular structure is less broken down by decomposition may be dewatered by mechanical pressure much more readily, and to a much greater extent than the older, well-humified peat which is best adapted for the production of fuel. Experiments by Dr. Raapke[1] showed that a fibrous new peat put under a pressure of 100 atmospheres parted with one-half of its water content in three minutes, whereas a well-humified, older peat gave up less than one-tenth of its contained water under the same conditions. In the case of the young peat, continuance of the same pressure for 50 minutes removed over three-quarters of the contained water, so that the water content was reduced below 66 per cent. At the end of the same period under the same pressure only about one-quarter of the water had been removed from the well-humified peat, and the remaining water content was still about 87 per cent. The accompanying curves, Figure 10, showing the results obtained, indicate clearly that time of pressing is the ruling factor, and that increase of pressure produces comparatively slight effect. Not only is the low rate of speed with which the water can be removed fundamental, but the final result obtainable is limited, and varies greatly for different classes of peat. The limit of effective application of pressure is quickly approached in the treatment of young peat, whereas with the older, well-humified peat the reduction of the water content below 80 per cent is difficult even after long continued pressure.

ELECTRICAL TREATMENT OF PEAT FOR REMOVAL OF WATER

Electro-osmosis

A difference of potential sending an electric current through a two-phase system of liquid and solid may produce a relative displacement of the phases. If the solid is fixed in the form of a porous diaphragm, the liquid may move through the diaphragm (Electrical endosmose). If the solid is in the form of a suspension, the solid may migrate through the liquid (Cataphoresis).

Count von Schwerin of Wildenhoff, Germany, devised methods for the "electrosmotic dehydration of peat" based on this principle, in which the suspended solid tends to migrate towards one electrode while the water flows to the other and is removed, the process therefore not being one of true drying, but of mechanical removal of water.[2]

The raw peat was submitted to a preliminary pulping process to reduce it to a uniform pasty consistency. With a potential gradient of 4 or 5 volts per centimetre, a power consumption of 13 to 15 kw. hours is stated to have been required for the removal of 1,000 kilograms of water, which was accomplished with the aid of pressure or suction.

By this means the water content of the raw peat could not be reduced below 70 per cent, leaving a large amount of water to be subsequently removed by evaporation. The process was adopted by the Hoechst Dye Works and put in operation at the East Prussian Pentane Works, near Tilsit, the product bearing the trade name "Osmone."

[1] Keppeler, Prof. Dr. G.—Die Methoden zur Künstlichen Entwässerung von Rohtorf. Brenstoff-Chemie., Nos. 15, 16, 17 Bd. 3, 1922.

[2] Electrical Endosmose, by T. R. Briggs, Jour. Phys. Chem. Vol. XXI, 1917.

From 1·5 cubic metre of raw peat containing 87 per cent water there was obtained 1 cubic metre of "osmosed peat" containing 70 per cent water, and when this was further air-dried under cover it produced 169 kilograms of Osmone with 15 per cent moisture.[1]

From the economic standpoint the results attained bore no comparison with the running expenses and cost of equipment. Not only the Pentane Works, but Osmone, Ltd. which was established at Berne, Switzerland, in 1905, with a share capital of 1,800,000 francs, resulted in failure.

Various arrangements for carrying out the process of electro-osmosis were made by Moller and Pfeiffer, Schwarzer, Diamant, Adler, Kittler, and others. Efforts were made to obtain greater efficiency by adding alkaline substances or salts to the peat to be treated, by employing intermittent pressure in conjunction with electrical osmosis, by leading heated air through the peat during the passage of the electric current, etc., but none of these means served to make it a success.

Kerrinne's method of drying peat by electric energy was also tried at the Pentane Works[2]. From a disintegrator the raw peat was fed into wooden moulds with bottoms of fine brass wire net on which the peat mass rested in a layer 2 inches thick. The brass wire nets acted as cathodes, and 0·3-inch thick iron plates of the same dimensions as the interior dimensions of the moulds as anodes. The iron plates could be raised or lowered by means of a lever, and when a section was filled with moulds the plates were lowered on the peat mass, following it as it sank. After 4 hours, when the current was switched off, the water content of the peat had been reduced from 90 to 80 per cent. The electrically treated peat was then formed into briquettes and remained from 24 to 30 hours in a Moller and Pfeiffer drying-oven, heated with waste steam from the engines, which further reduced the water content to about 70 per cent. Air-drying was resorted to for completion of the manufacture of the fuel. The briquettes made were in no way superior to ordinary air-dried machine-peat fuel, and the cost of manufacture was naturally much greater.

Electro-peat-coal

Under J. B. Bessey's process for production of the so-called "electro-peat-coal"[3] the raw peat after disintegration was subjected to gradually increased pressure in a rotary "hydro-eliminator" to remove a portion of the water. It then passed to an electrifying machine in which it was continuously pushed forward by a reciprocating plunger, and meanwhile subjected to a powerful alternating current with the purpose of freeing additional water and bringing the peat into such condition that the released water could be easily extracted by means of a second hydro-eliminator, after which it was kneaded and moulded into briquettes. Since no coking took place and the calorific value of the peat was in no way increased, the name given to the product was entirely misleading. It is apparent that no greater efficiency in removal of water could be expected by this process than by that of von Schwerin, viz.: a reduction of the water content to 70 per cent, and that to turn out a finished fuel further treatment would be

[1] Handbook on the Winning and the Utilization of Peat, by A. Hausding.
[2] Peat and Lignite, by E. Nystrom, p. 158, citing A. Larson, Teknisk Tidskrift, No. 42, 1903.
[3] Peat, its Use and Manufacture, by P. R. Björling and F. T .Gissing.

required. A plant designed to handle 300 tons of raw peat daily was erected at Kilbery, Ireland, but proved a complete failure. An attempt was also made in the United States to utilize the process at a plant erected near Eaton Rapids, Michigan, but this also failed though well supported by capital and equipped with unusual thoroughness.[1]

Other electrical dehydrating processes have also been tried, but without commercial success in any case. The small result attained in comparison with the cost of equipment and operation, and the further difficulties encountered in producing a fuel in serviceable form from the peat, only partially dried by all such processes, preclude the possibility of their being employed with success in commercial operation.

THE EKENBERG PROCESS

As already pointed out the reason why the water content of raw peat cannot be expelled by mechanical pressure is that well-humified peat possesses the properties of colloids and contains a certain amount of a true colloid, called by some investigators hydro-cellulose. The solid substance in colloids exists in such a finely divided state, that the particles of which it is composed, behave in a manner similar to molecules. This finely divided matter when mixed with many times its own weight of water remains in suspension and the attraction between the molecules of water and the particles of the substance in suspension is so great that any opening which is sufficiently large to permit the passage of a molecule of water, will also permit the particles of the substance in suspension to pass through, or else the particles of matter will clog the opening, and, by virtue of the above-mentioned attraction, will prevent the molecules of water from passing through. This has for a number of years past been recognized by scientific investigators, and although attempts to dehydrate raw peat by pressure have been abandoned, efforts have been concentrated on destroying the colloidal properties of the peat, so that it will give up its water content more readily.

Dr. Martin Ekenberg, a Swedish engineer resident in London, England, began experiments along this line soon after 1900, directing his attention to accomplishing the destruction of the colloidal properties by strongly heating the raw peat in a closed vessel under pressure. After subjecting the raw peat to a temperature of 180°C. he succeeded in pressing well-humified peat in a laboratory screw press so that the pressed cake contained only 30 per cent moisture, equivalent to removal of about 90 per cent of the original water contained in the peat as dug from the bog[2].

The result of laboratory experiments being thought very promising, a plant was erected at Stafsjo, Sweden, to carry out the process on a sufficiently large scale to demonstrate its commercial possibilities, the Swedish Government contributing 20,000 kronor towards the cost of its establishment. This plant was operated during 1904-5, being supervised in the latter part of 1905 by Mr. Alfred Larson on behalf of the Swedish Department of Agriculture. As a result of the operation of this small plant it was estimated that in a plant producing 30,000 tons of briquettes yearly, the production cost of the fuel would be about \$2.25 per ton. Failing,

[1] The Uses of Peat for Fuel and other Purposes, by C. A. Davis, U.S. Bureau of Mines, Bulletin No. 16, 1911.
[2] Peat and Lignite, by E. Nystrom, No. 19, Mines Branch, Dept. of Mines, Canada.

however, to induce the Swedish Government to assist in further developing the process Dr. Ekenberg returned to London, and in 1907 a company known as "The International Carbonizing Company, Limited," was formed, with a nominal capital of £41,000, and later a syndicate with a paid-up capital of £35,000 was organized to develop the process. The syndicate built a small plant at Dumfries, Scotland, and continued experimental work until 1911. In 1912 a new company was formed, called Wet Carbonizing, Limited, with a paid-up capital of £250,000. The capital of this company in 1919 was £1,000,000 of which £900,000 was paid up.[1]

During the first years of the war the plant was closed down, no commercial success in production of fuel or recovery of by-products having been attained, although very heavy expenditures had been made over a period of several years.

The Ministry of War, having found that the wet-carbonized briquettes were a smokeless fuel and, therefore, particularly suitable for use in the trenches, took over the property as it stood in 1917, and, with the benefit of the experience gained, erected a new plant, designed on a large industrial scale, for the production of 60,000 tons of briquettes per annum. The new plant, which was well designed and thoroughly equipped, and built at the expense of the British Government, was not completed until after the close of the war, when it was turned over to the company for operation, and regular manufacturing of fuel was begun in October, 1919.

Operation of the plant was made feasible by the utilization of slack coal as fuel, the maximum price for which, under government regulations prevailing at the time, was fixed at 30 shillings per ton, and owing to the heavy demand for fuel, the briquettes produced could be sold, free from restriction, at 90 shillings or more per ton.

In November of the same year a Swedish Government Commission visited the plant, special trial runs were conducted and a report on its operation was made by J. O. Roos of Hjelmsater,[1] Director of the Government Testing Laboratories at Stockholm, which affords the following data:— Estimated production of briquettes: 60,000 tons per annum. Actual production: 130 tons per 24 hours, or 40,000 tons per annum. Number of men employed: 250. Volume of buildings housing plant, approximately 1,650,000 cubic feet. Power requirements: 1,050 kilowatts. Comparative fuel value: 1 ton briquettes equal in effective value to 0·65 ton best English steam coal. The decisive factor, however, which determined the economic value of the process, was the very large heat requirement. Observation of production of briquettes and consumption of fuel during the 24-hour periods of regular operation showed the following results.

	Briquettes made, tons	Coal used, tons
First 24-hour period	132	114
Second 24-hour period	140	128
Average per 24 hours	136	121

Analyses gave an effective calorific value of the briquettes of 4,380 calories as against 5,300 calories for the slack coal used. The average number of effective calories produced and consumed daily were:

Briquettes made	596,000,000 calories
Coal consumed	641,000,000 "

[1] Torfkoltillverkningen vid Dumfries, Skottland, J. O. Roos, Hjelmsater-Teknisk Tidskrift, 17 April, 1920.

From this it may be seen that more calories were consumed than produced, and from an economic point of view, regarded as a means of increasing fuel supply, the results were absolutely nil. Moreover, if the peat briquettes produced had been used as fuel for the plant, the entire output would have been consumed leaving no balance for sale.

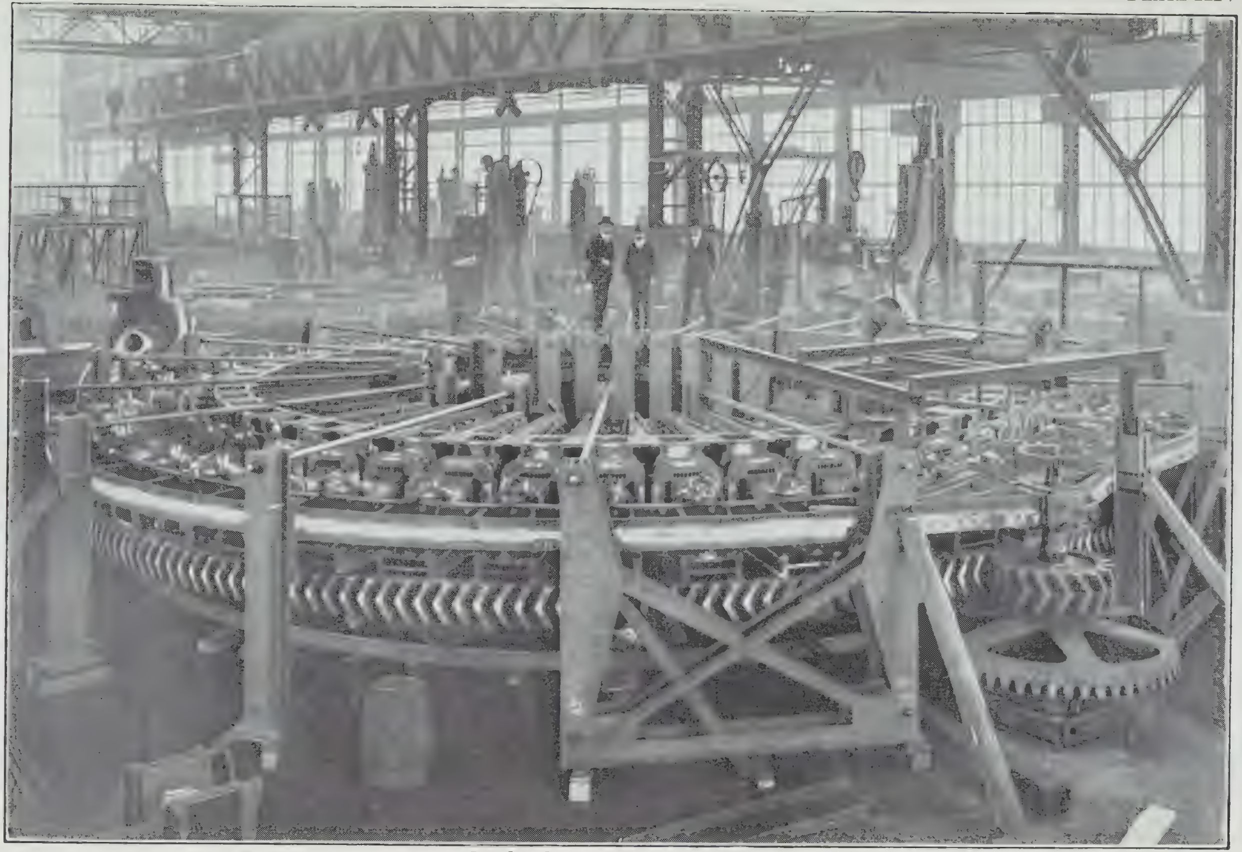
A translation of the above-mentioned report, which appears as an appendix hereto, furnishes additional detailed information with regard to the plant, process, and operations.

A serious technical difficulty in carrying out the process arises from the fact that raw peat contains certain humus acids which during the wet-carbonization are changed into other acids which attack the wet-carbonizing tubes, reducing their length of life to only three to six months. These acids must therefore be neutralized. At the Dumfries plant neutralization was effected by means of the addition of slaked lime to the peat in an amount of 3 to 4 per cent of the dry substance of the peat. This not only considerably increased the ash content of the briquettes but caused precipitation of lime salts in the tubes where lower temperatures prevailed. The deposit so formed consisted generally of oxalate of lime which was rapidly formed to such thickness that the transfer of heat from the hot wet-carbonized peat through the tubes to the cold peat slop became so poor that the calorimetric efficiency was much reduced, and it became necessary to scrape the tubes every fourth day, an operation for which 5 to 7 men per shift were required.

Apart from technical difficulties in operation and the extremely poor production efficiency obtained in relation to the heat consumption required, the complexity of the process, and the very high plant costs involved, as well as the cost of operation render it uneconomic and incapable of being put into successful commercial operation.

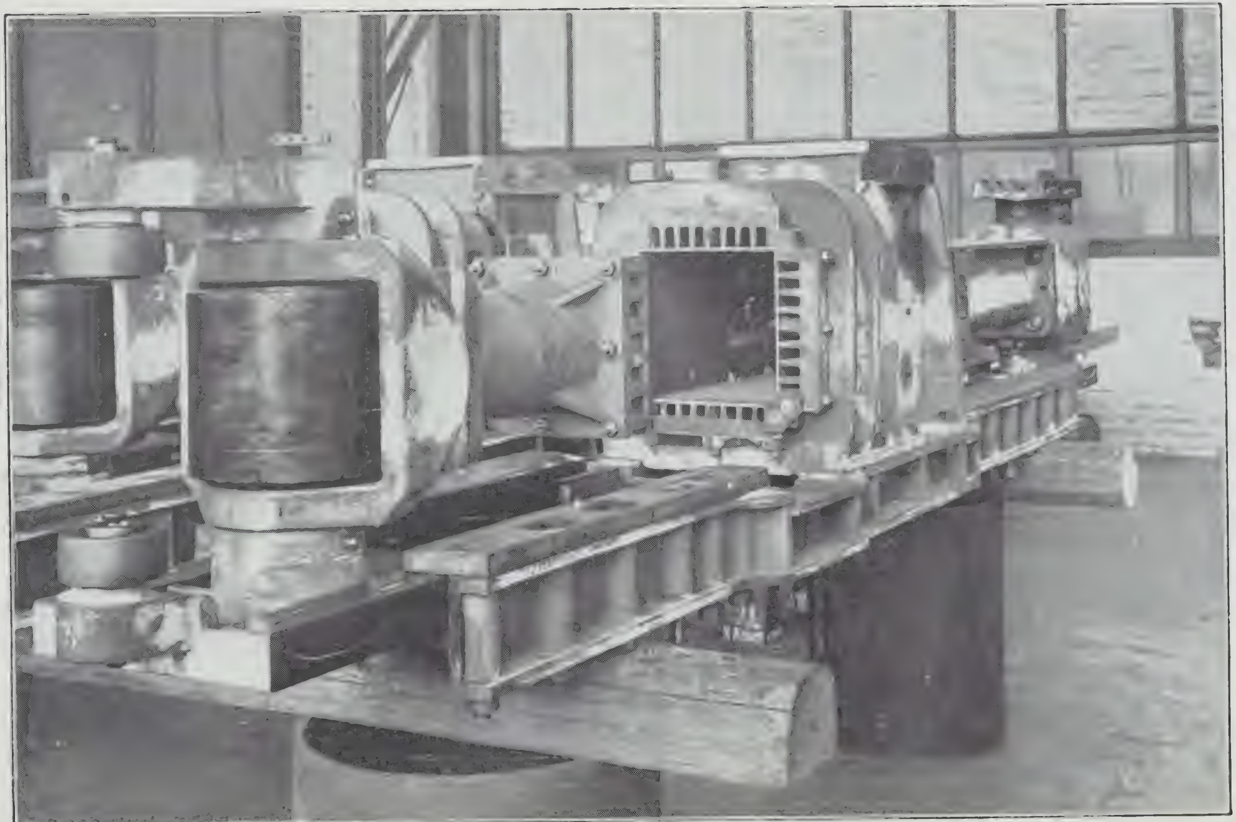
The technical staff of the company estimated that by certain improvements a 60 per cent efficiency could be obtained, i.e., 60 per cent of the briquettes made, would be available for sale while 40 per cent would be consumed by the plant. The fact that after many years of experimental work and enormous expenditures of money, in a plant erected under most favourable conditions, with the best engineering skill and unlimited funds available, only a negative efficiency was actually obtained, renders it certain that such an estimate is highly optimistic, especially since the complications of the plant and process render it exceedingly difficult to estimate the efficiency obtainable, and to provide for the many unforeseen circumstances and conditions which must arise in actual practice.

Reporting on the feasibility of establishing a similar plant in Sweden, Mr. Roos estimated that, even if it were assumed that by the suggested improvements an efficiency of 50 per cent could be obtained, in order to produce 40,000 tons of saleable briquettes, the plant must be capable of producing 80,000 tons, one-half of which would be consumed in the process, and that the cost of such a plant in Sweden would be from 12,000,000 to 15,000,000 kronor ($2,400,000 to $3,000,000 at pre-war exchange rates). Moreover, briquettes made in such a plant would cost 100 kronor per ton, and could not compete with best English steam coal when its price was below 155 kronor per ton.



Madruck ring press mounted

PLATE XV



One cylinder and press chamber, Madruck ring press

THE MADRUCK PROCESS

This process at the present time is regarded as the one promising the best economic results of any of the various methods tried for the purpose of avoiding the delays and seasonal limitations of air-drying of peat. It is based on the theory that the colloidal character of raw peat may be so altered by mixing with it a finely divided additional substance, that the surface tension of the water retained by capillarity and the pressure exercised by the swelling of the peat are decreased, thereby rendering the material more amenable to the removal of water by mechanical pressure. For this purpose dry peat containing up to about 30 per cent moisture, and finely ground, is thoroughly mixed with the raw peat, and the mixture subjected to pressure.

Operation of the Process[1]

The excavated raw peat is carried to a store pit from which it is transported by elevator and belt conveyer to disintegrators which finely divide the peat, without kneading it, this being an essential feature of the process. The disintegrated peat falls on a belt conveyer covered by a layer of predried peat containing 30 per cent water, and is conveyed to a mixer where the raw peat and dry peat are thoroughly but loosely mixed. The mixture is then fed into the press chambers of the ring press, from which it is discharged in the form of cakes about 12 inches square and 6 inches thick, with water content of about 60 per cent. Part of these cakes are broken up, placed in a tubular drier to reduce the water content to 30 per cent, and finally crushed and fed on to the belt conveyer above mentioned, where they re-enter the process and are mixed with a fresh supply of raw peat. Another portion of the press cakes is fired on step grates under boilers to furnish power and heat requirements of the process. The remaining press cakes are crushed and dried down to 15 per cent moisture content in a tubular drier, after which they are pulverized and formed into briquettes by means of a briquetting press.

The Madruck Ring Press and its Operation

On a circular revolving table supported by wheels running on rails about the rim, 48 press elements are radially mounted. (Plate XIV.) In the open ends of the press chamber of each of these elements, two opposing press pistons are inserted. (Plate XV.) These pistons make the circuit of the table with the press chambers into which they are forced by means of stationary guide rims. The outer ends of the pistons rest on pressure rollers which travel on the guide rims, their movement with respect to the press chambers being regulated by the curved rims.

[1] Archiv fur Warmewirtschaft, No. 12, 1921 pp. 179-180.

The movement of the pistons in the press chambers is shown by the accompanying diagram (Figure 11). At the point "Position for filling" the pistons are in such position that there is an open space of about 300 millimetres at the inner end of the press chamber. This is open above and is filled at this point with the material to be pressed. By clockwise revolution of the table the press chamber and pistons arrive at the point "Beginning of pressing". The inner piston K1 is, by means of a pressure roller K1 which runs on a curve F1 of the guide rim F1, forced into the chamber, while the outer piston K2 through the running of its counter-roller K2 on the curve F2 of the guide rim F2 is withdrawn to the outer end of the press chamber.

The material to be pressed is now in the press chamber, the walls of which, as well as the piston faces, are made of specially perforated metal plates that allow the water to escape.

During five-sixths of the further revolution of the table both the inner and outer pistons with their pressure rollers rest against the inner and outer guide rims F1 and F2. The outer curve is first centric up to the point A, while the inner curve is eccentric approaching the outer curve until the "End of pressing" is reached. By this means the inner piston approaches the outer piston which remains stationary in relation to the press chamber, at first rapidly and later with reduced velocity according to the velocity curve adapted to the material to be treated. The volume of the press chamber is constantly reduced while the pressure increases as part of the water flows out of the peat. By further revolution of the table the outer piston with its roller is made to advance to A by an eccentric portion of its guide curve, and is forced into the chamber. Pressure is thus applied on both sides of the material thereby avoiding the formation of a zone of higher water content on the outer side of the press cake, due to the effect of frictional resistance from the chamber walls, as would be the case if all the pressing were effected by one piston only.

From the "End of pressing" to "Point of discharge" both pistons are moved outward with an increase of the distance between them. By moving along the curves F3 and F4 the outer piston is drawn out of the press chamber, while the inner piston is forced into it until its face is flush with the outer end of the chamber. The press cake thereby ejected falls through an opening in the revolving table on to a belt conveyer not shown in the diagram. The curves F5 and F6 bring both pistons again to their original position in readiness for the recharging of the press chamber. By one revolution of the table in an average time of about five minutes, 48 press chambers successively follow the procedure described, so that in this time 48 press cakes are made.

Discussion of Process in Former Report

The process, which has been elaborated by Messrs. Brune and Horst, was, during the initial stages of its development, investigated and discussed by the writer in a former report issued by the Mines Branch.[1] It was there shown that if 100 pounds of peat containing 20 per cent moisture is mixed with 300 pounds of raw peat containing 87½ per cent moisture, and by application of mechanical pressure a press cake containing 53 per

[1] Peat, Lignite and Coal, by B. F. Haanel, No. 299, Mines Branch, Dept. of Mines, Canada.

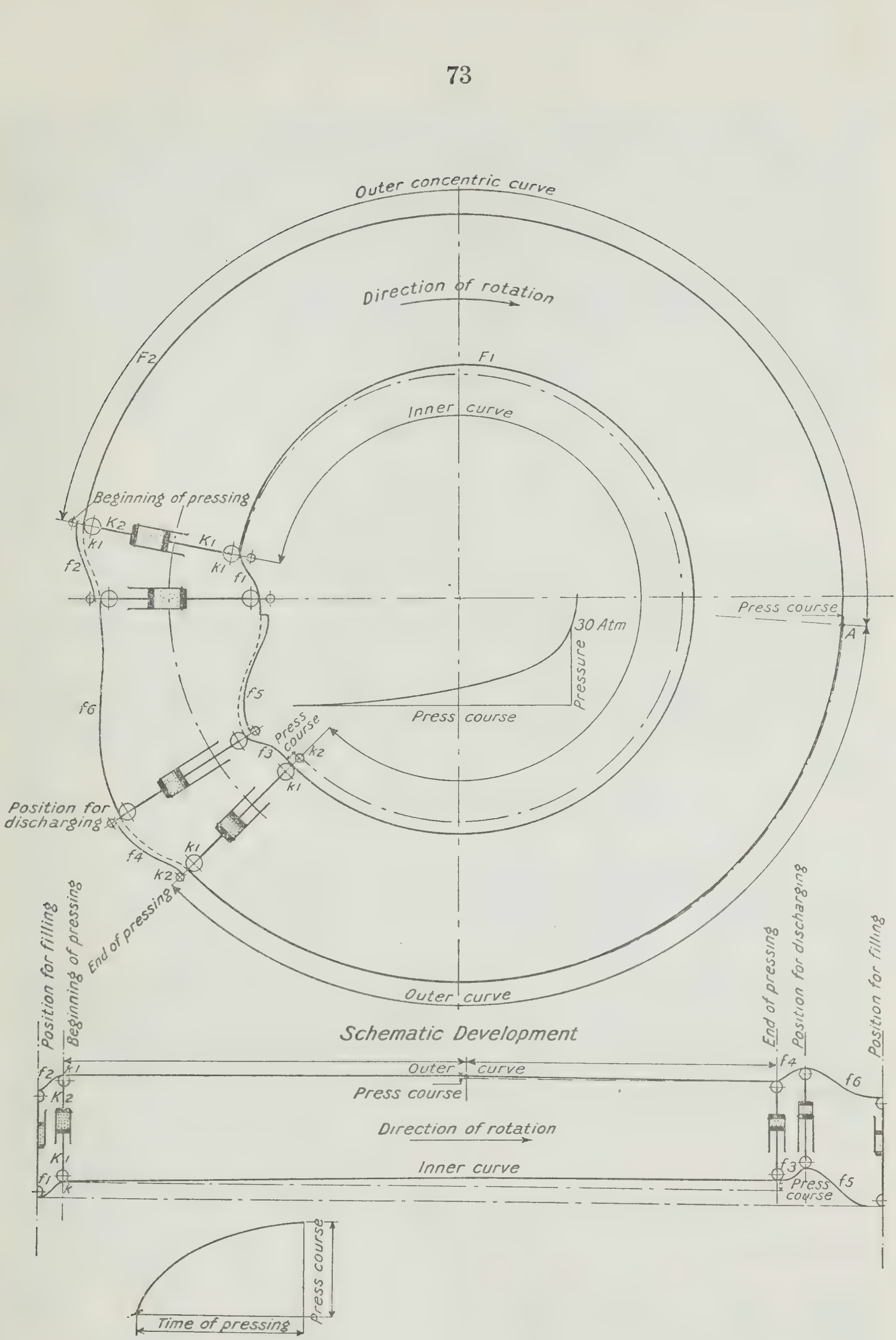


FIGURE 11. Diagram to show operation of Maduck ring press

cent moisture is obtained, the resultant dehydration of the raw peat accomplished is merely the equivalent of its reduction to 75 per cent moisture content by an ordinary hydraulic press without admixture of dry material. It was further pointed out that reduction of the moisture content of the raw peat from 87½ to 75 per cent is quite possible with ordinary presses, but that difficulty arises when attempts are made to reduce the moisture content below 75 per cent. Also that the evaporation of water by artificial heat necessary to obtain from the press cakes a final product containing 20 per cent moisture would require the consumption of about one-half of the product manufactured. The opinion was therefore expressed that the process was not economic. According to more recent data received it is now proposed to add dry peat only to the extent of 12 per cent of the weight of the raw peat to be pressed.

Experiments Conducted in Bavaria

During investigations conducted at Munich in 1920 by Dipl. Ing. H. Gross [1] for the Technical Department for Peat Industry of the Munich Government Institution for Bog Culture, tests were made with samples of peat from a number of bogs, and the results were divided into three classes according to the nature of the peat treated.

Class I comprised peat from low bogs which was most readily susceptible to dehydration by pressure. Class II comprised peat from high bogs more difficult of dehydration than Class I, and Class III consisted of samples from a transition bog with well-humified peat and still more difficult to dewater.

It should be borne in mind that the quality of the fuel is a function of humification, in other words the greater the degree of humification the better the quality of the fuel which can be manufactured from the raw peat substance, but on the other hand, the greater the degree of humification the more difficult it becomes to extract water from the raw peat by pressure, since its colloidal properties are increased.

Experiments with various admixtures demonstrated that the most favourable results were obtained by the addition of dry peat containing 20 to 30 per cent moisture in the proportion of 1 pound dry substance in the added dry peat to 1·5 pounds dry substance in the raw peat. By a single pressing for 6 minutes under a pressure rising to 450 pounds to the square inch the following average results were obtained.

—	Water content per cent			Equivalent to reduction of water content of raw peat to
	Raw peat	Added dry peat	Mixture after pressure	
Class I	89·1	25·3	63·6	72·8
Class II	88·7	19·5	66·3	75·8
Class III	89·75	18·6	71·1	79·7
Average	89·18	21·1	67·0	76·1

[1] Untersuchungen über die Eignung bayerischer Moore für das Madruck-Verfahren von Dipl. Ing. Hans Fr. Gross, Techn. Abt. für Torfwirtschaft, München.

It was also sought to ascertain what effects could be obtained in the further removal of water by additional pressing and using higher pressure. Press cakes obtained from the first pressing were disintegrated and subjected to a second pressing for a 4-minute period under a pressure rising to 450 pounds per square inch. In a number of instances a third pressing was made which was continued for 12 minutes with pressure rising to 2,400 pounds per square inch. The percentages of contained water extracted were:

—	Water content of mixture	Per cent of water removed by pressing		
	Per cent	1st	2nd	3rd
Class I	83·3	54·6	6·9	4·3
Class II	83·1	48·8	8·9	7·2
Class III	84·3	45·3	12·3	7·2
Average	83·6	49·5	9·3	6·5

It will be noted that by a single pressing less than 50 per cent of the contained water was removed, and that the results of the subsequent pressings were so small, even with the high pressure of 2,400 pounds per square inch, as to be clearly uneconomic in commercial operation. Also that the moisture content of the mixture after a single pressing averaged 67 per cent equivalent to dehydration of the raw peat to 76 per cent moisture content. It should be further taken into account that the charge of raw peat treated in the tests was only 2 kilograms (4·4 pounds) and equally favourable results are not to be expected when the larger press chambers necessary for large-scale production are employed.

Calculated Operating Results on Commercial Scale

In commercial application of the process in a plant in Russia it is proposed to effect partial dehydration of the raw peat, by a single pressing in a continuously moving ring press supplied with 48 press chambers each containing a charge of 32 kilograms (70·4 pounds) of a mixture of dry peat and raw peat in the proportion of 12 : 100. The press will make one revolution in 4 minutes, corresponding to an effective press operation of about 3·4 minutes, deducting time required for filling and discharging the chambers. During the effective period of 3·4 minutes the pressure slowly rises to a final pressure of 450 pounds per square inch. The calculated operating results to be obtained according to data furnished by the company[1] are as follows:—

The raw peat is assumed to have an average moisture content of 87½ per cent.

Dry peat with 25 per cent moisture content is added in the proportion of 12 : 100 of raw peat.

			Dry substance	Water
Raw peat treated per 24-hr. day	495·0	metric tons being	61·9 tons	433·1 tons
Admixture "	59·4	"	44·5 "	14·9 "
	554·4	"	106·4	448·0 "

[1] Detailed information with regard to the Madruck process, with photographs and drawings illustrating same, has been included in this report, through the courtesy of Techno-Service Corporation, 46 West Fortieth Street, New York.

Mixture to be dehydrated to 60 per cent leaving 266·1 tons of press cakes, or 106·4 tons of dry substance and 159·7 tons of water.

Amount of water extracted (448-159·7) = 288·3 tons = 66·5 per cent of water in the raw peat.

Disposal of the 266·1 tons of press cakes is as follows:—

111·4 tons containing 44·5 tons dry substance and 66·9 tons water to be passed through a tubular drier and by evaporation of 52 tons of water to be reduced to 25 per cent water content, finely ground, and returned to press for continuance of operation. This proportion, amounting to 41·8 per cent of the total output of the press, must be constantly returned to the press forming a continuous cycle altogether outside of the effective output, which is therefore only 154·7 tons of press cakes daily.

67·3 tons used as fuel under the boilers to produce power and heat required for operation.

If the calculations are correct 363 h.p. are required for operating the plant and 55 h.p. for field work. Heat for the latter is to be provided by the consumption of 2·4 tons of waste peat and wood daily. Heat must also be provided for the evaporation of 98 tons of water daily. According to the computation, $\frac{67 \cdot 3 \times 100}{154 \cdot 7} = 43\frac{1}{2}$ per cent of the entire effective output of the press is consumed for production of heat and power, 87·4 tons remain as the total effective daily output of press cakes containing 60 per cent moisture. By evaporation of 46 tons of water this is reduced to 41·4 tons of material with 15 per cent moisture ready for briquetting. Assuming 1 per cent loss by dust, the output per day of 24 hours will be 41 tons of briquettes with 15 per cent moisture content.

It is assumed that work will be continuous throughout the year giving a period of 300 working days and an annual production of 12,000 tons of briquettes. Physical conditions on a bog during the Canadian winter, however, are such as to render the practicability of continuous operation extremely improbable, and to make winter operation very costly if not impossible. For a period of three to four months excavating of raw peat cannot be carried on, and since about 360 cubic metres of raw peat are required daily, covered and warm storage would have to be provided for approximately 48,000 cubic metres of raw peat to keep the plant going during the winter months. Considering the high capital cost and expense of operation of the plant, and the fact that nearly one-half of the total fuel produced must be consumed to provide heat and power for the operations it does not appear that the process is likely to prove economic even on the basis of the calculations of its promoters. Whether calculated results can be obtained in large-scale commercial operation is, also, open to grave doubt, as clearly indicated by the following comparison:—

——	Bavarian Government tests [1]	Madruck calculations for commercial plant
Charge per unit press chamber	5 lbs.	70·4 lbs.
Pressure rising to	450 lbs. sq. in.	450 lbs. sq. in.
Period of effective pressure	6 min.	3·4 min.
Raw peat, water content, average	89·18 per cent	87·5 per cent
Admixture, water content	21·1 "	25·0 "
Press cakes, water content	67·0 "	60·0 "
Equivalent reduction of water content of raw peat to	76·1 "	70·0 "

[1] Das Madruck verfahron für Maschinellen Entwässerung von Rohtory (Richard Pflaum, München).

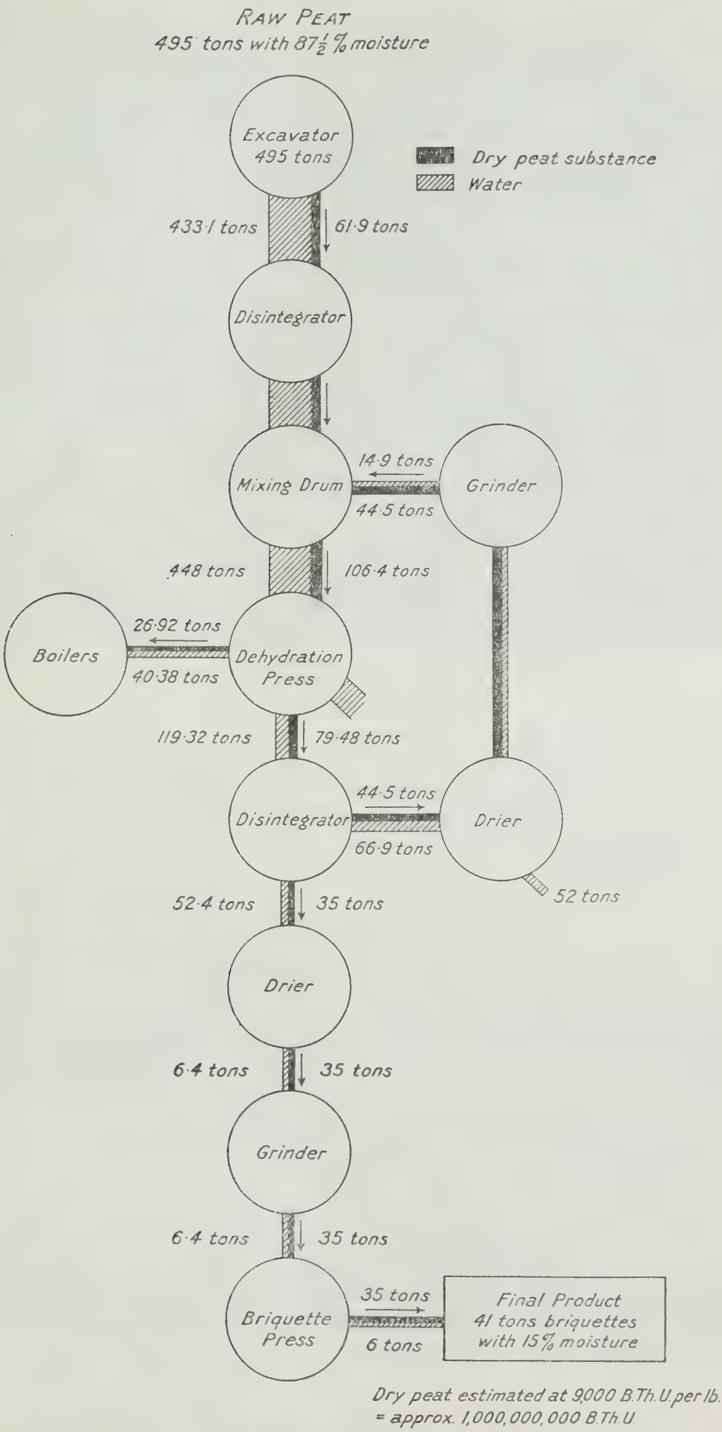


FIGURE 12. Flow-sheet of material in Madruck process

If the expected results of the commercial plant are to be realized, then with 14 times greater charge per unit, subjected to the same pressure for a little over half the time, more water must be removed from the peat than was accomplished on a laboratory scale in the official tests cited.

Figures 12 and 13 are flow-sheets showing steps in the manufacture of peat fuel according to the Madruck process and the air-dried machine-peat process respectively.

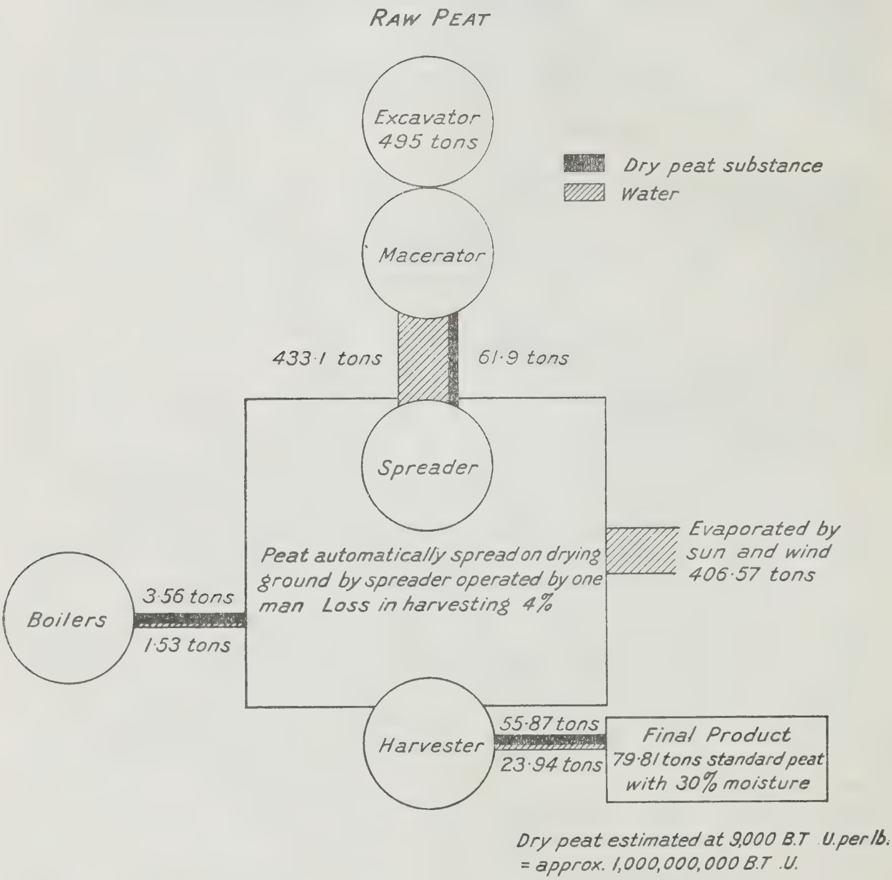
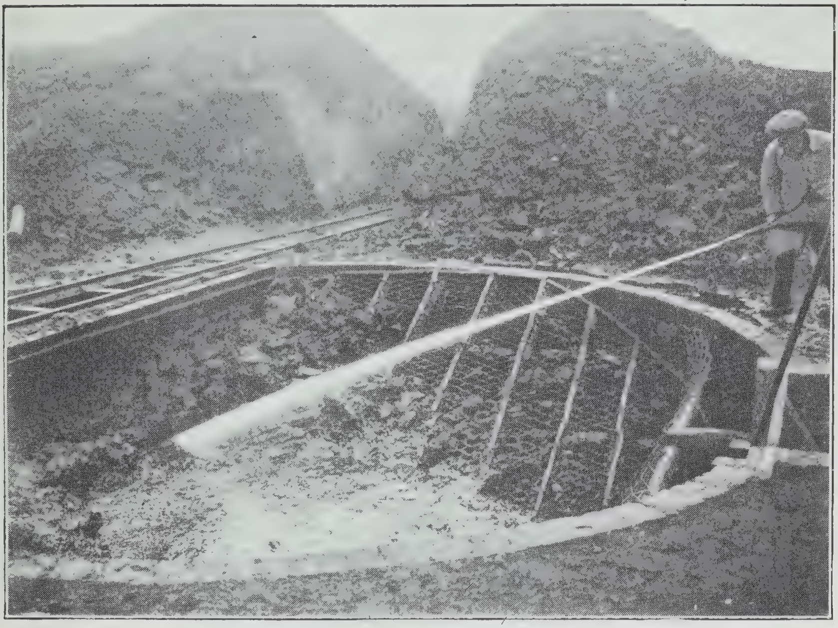


FIGURE 13. Flow-sheet of material in air-drying process

THE MIGEON PROCESS

The following method of peat winning has been adopted in connexion with a peat distillation plant installed at Postel, Belgium, to operate under processes invented by Marcel Migeon.

PLATE XVI



Masonry tank, with expanded metal bottom, used in Migeon process.

PLATE XVII

Stationary conduit leading to drying-area, used in Migeon process.

Plate XVIII

Hydraulic excavation of peat on Lundergaard bog, Denmark

Plate XIX

Pump-house resting on piles, substituted for movable crane

The bog is prepared by draining, and the raw peat excavated by a cutting machine. Mixed with large quantities of water, the excavated peat is forced through metallic gutters into a masonry tank located at the centre of the plant.

The tank is provided with a false bottom of expanded metal supported by transverse joists (Plate XVI). The dilute slimes of the peat fall to the bottom of the tank, and the fibrous parts are retained on the metallic screen, where they are disintegrated by a powerful water-jet. The whole finally forms a much diluted pulp which is recovered from the bottom of the tank by means of a specially constructed pump and forced through a stationary cement conduit to the spreading-ground (Plate XVII).

Two days after the semi-fluid pulp has been delivered to the spreading-ground the solid particles which were in suspension have settled and the free water can be drained off. Four days later a disk cutter is run through the bed of peat dividing it into blocks of the required size, which are left exposed to the air until they have a moisture content of between 50 and 60 per cent, when they are collected and stored under cover. In the shed the partly dried blocks are laid horizontally between beds of faggot hurdles, so that drying proceeds slowly. Final reduction of the moisture content to 25 per cent, as required, is effected by means of employment of waste heat from the distillation plant.

In the operation of this process, pulp with 93·6 per cent water content deposited on August 12th was cut into blocks on August 18th. Six days later the blocks were set on end to promote drying and on September 4th, twenty-three days after excavation, were removed to the sheds with 58·2 per cent water content.

HYDRAULIC EXCAVATION

The presence of large numbers of roots, stumps, and buried tree trunks in some bogs makes excavation by any of the ordinary methods difficult. To deal with such conditions it has been frequently proposed to excavate the peat by employing powerful jets of water.

This process was first tried in Germany, at the Pentane Works in East Prussia and later, during the war, by the Prussian Government at Linium. The results of these trials are unknown. More recently it has been employed at the large peat-fuel-using power station at Bogorodsk near Moscow, in Russia. In 1920 a "hydro-peat" plant was installed at Juurikorpi in Finland and in the following year an installation was made on the Store Vildmose in North Jutland, Denmark.[1]

It is claimed that in Germany an output of 6,500 tons of air-dried peat has been obtained by this process in 75 working days of 10 hours each, being an average of over 9 tons per hour, eleven men being required for operating where the bog contained roots.[2]

[1] The Production of Air-dried Peat, Report of the British Fuel Research Board for the years 1922, 1923.
[2] Deutsche Torfindustrie Leitung, February 12, 1922.

THE HYDRO-PEAT PROCESS

LUNDERGAARD PEAT BOG, DENMARK

Description

The peat in the bog is disintegrated and reduced to a thin liquid pulp, containing about 95 per cent water, by the agency of water-jets directed against the sides of the excavation under a pressure of 6 to 8 atmospheres. Two nozzles are used ($\frac{3}{4}$-inch and 1-inch) mounted on wheels (Plate XVIII) and attached to lengths of hose which permit their operation at a considerable distance from the pump-house. The thin pulp washed down into the excavation is drawn from the bog by a suction pump and conducted through pipe lines to a reservoir adjacent to the drying-ground.

Formerly the suction pump was supported on a movable crane, but for this there has been substituted a pump-house resting on piles which are driven into the bog in advance as excavation proceeds, and withdrawn when the peat has been removed. (Plate XIX.) The width of the section of bog excavated is from 150 to 200 feet. The working end of the excavation, adjacent to the pump-house, is however kept narrow to facilitate the action of the pump. The pump-house is moved ahead along the line of excavation about twice a week, and can be moved in an hour by the men on the bog.

The conduit through which the peat pulp is transported to the drying-ground is about 1,100 metres in length, and is composed of short sections of pipe with a diameter of 400 millimetres (about 16 inches).

The drying-ground has an area of about 75 acres, and is located on firm ground adjacent to the bog. The general scheme of the layout and plan of operation will be made clear by reference to the accompanying sketch. (Figure 14.)

A line of pipes is laid down the centre of the area to be spread. On each side of this line, and at right angles to it, shallow ditches are dug at intervals of about 70 feet. The material thrown up from these ditches forms low dykes on either side of them, which serve to retain the thin peat pulp when spread to a depth of 6 or 7 inches, and the drying-ground is thus divided into long narrow strips. A line of pipes, connected up to the main pipe line, is laid down the centre of one of these strips, and the thin peat pulp pumped through them on the drying-ground. As the peat is spread to the desired depth sections of pipe are removed and placed in position for spreading on the adjacent strip. (Plate XX.)

The pipe sections are of light metal construction, about 6 feet in length, and are provided with handles by means of which they are easily moved by one man. They are simply flanged at one end, and the flange joints have neither screws nor packing, leakage being prevented by their clogging with peat.

With favourable weather conditions the peat spread becomes in a few hours sufficiently firm to permit of its being moulded into blocks. Two methods of effecting this have been employed. In the first a special

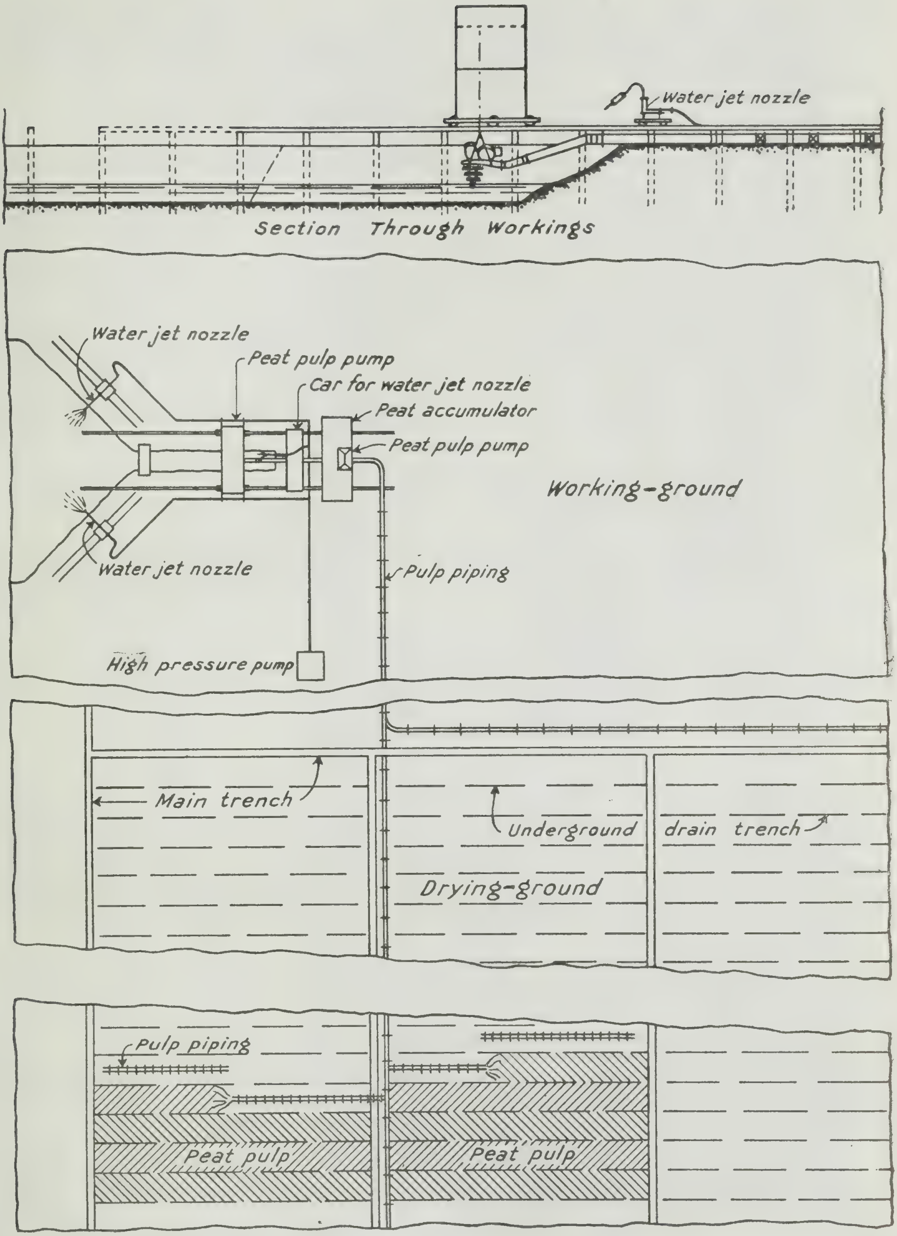


FIGURE 14. General layout of drying-area for spreading peat under Hydro-peat system

cutting-device (Plate XXI) was drawn along over the surface of the peat by a cable. This has been superseded by a motor tractor equipped with specially constructed drums for cutting the peat longitudinally and transversely. (Plate XXII.) Turning of the partly air-dried peat blocks is done by hand with an implement similar to a turnip hoe.

Labour. Twelve men in all were required to operate the plant. At the main power station two men attended the peat gas producer and gas engine, and on the drying-ground a third man ran the oil motor. At the bog one man managed the pumps, two handled the excavating nozzles, and a fourth did miscellaneous work. On the drying-ground four men spread the peat pulp and shifted the sections of pipe. There was also a foreman who, in addition to exercising general supervision of the work, operated the tractor device which formed the spread peat into blocks, this operation taking about an hour daily. Turning was done by contract at a cost of 20–25 öre per thousand blocks, being equivalent to 50–65 öre per ton. (1 Danish krone* = 100 öre.) Harvesting of the fuel and its transportation to railway cars or stacking were also done by contract at the following prices:—

To railway car: 25 kr. per 1,000 square metres of drying-ground yielding on an average 12½ tons of fuel, i.e., 2 kr. per ton.

To stack: 30 kr. per 1,000 square metres, i.e., 2·40 kr. per ton.

Power. The power requirements for operation were estimated to be 165 h.p., viz.:—

For the centrifugal pump to supply water	10 h.p.
For high pressure pump operating the water-jets	40 "
For the suction pump	75 "
For the centrifugal peat pump at reservoir	40 "
	165 h.p.

The main power installation comprised a peat gas producer, 120 h.p. gas engine, and three-phase, 125 kva. generator. Power for pumping the peat from the reservoir to the drying-ground was supplied by a 40 h.p. oil-motor. About 2 tons of hand-cut peat were required per 10-hr. day for the peat gas producer, and 62 kilograms of crude oil for the oil motor.

Water. About 100 cubic metres of water for the hydraulic excavation were supplied hourly from four artesian wells, each 4 inches in diameter and about 25 metres in depth.

Production. The capacity of production of the plant is stated to be 12 tons of 30 per cent moisture, air-dried peat fuel per hour. The output could be increased, employing the same equipment, by providing a larger power installation, and employing additional men.

The following estimate of cost of a hydro-peat plant for the production of 16 tons per hour, based on prevailing prices in Denmark, has been submitted by the engineer conducting the operations on the Lundergaard bog.

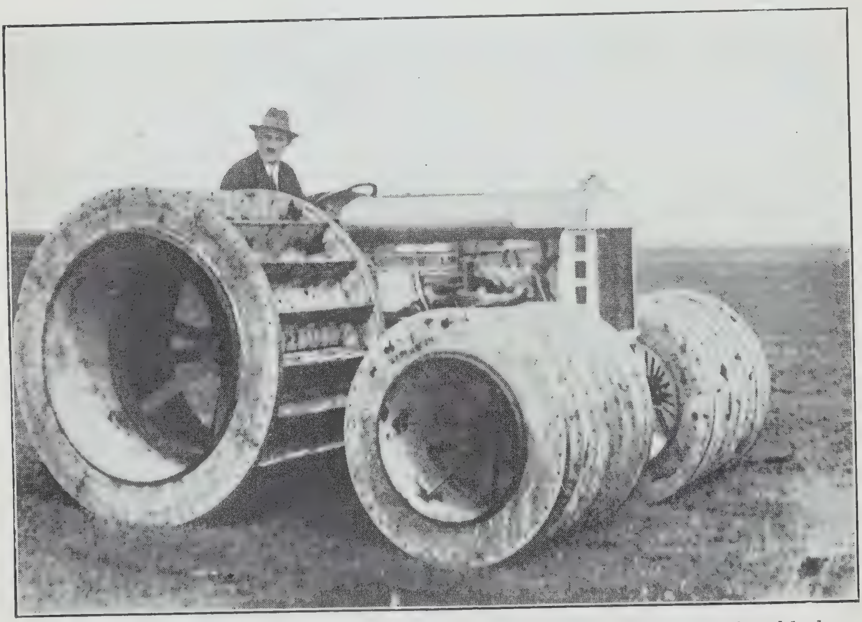
*Danish krone = 26·8 cents.

View on drying-ground showing movable pipe sections used for spreading raw peat in the hydro-peat process

Plate XXI

Cable-drawn device for cutting peat into blocks

Plate XXII



Motor tractor equipped with specially constructed drums for cutting peat into blocks

The distance of the excavation from the drying-ground is assumed to be 1,000 metres.

Hourly capacity of plant, 120 cubic metres of raw peat.

One cubic metre of raw peat is assumed to yield 150 kilograms of 30 per cent moisture peat fuel.

Working season 100 days of 10 hours, of which 90 days effective.

Annual capacity of plant, 108,000 cubic metres of raw peat.

Production of fuel per season, 16,000 tons.

Power requirements, 200 h.p.

Cost of Plant (Exclusive of Power Station)

	Kronen
1. Suction pump with 75 h.p. motor, including housing and pipe connexions	28,000
2. Pipe conduit (1,000 metres) to drying-ground	25,000
3. Centrifugal pump for 150 cubic metres of water per hour (9 atmospheres pressure) with direct-connected 75 h.p. motor	8,000
4. High pressure pipe conduit of 5-inch steam-pipes with bends, tees, and gates	9,000
5. 3 nozzles on special turntable stands, and provided with 30 metres jute hose	3,000
6. Moulding machine with motor	8,000
7. Centrifugal peat pump with motor (belt-driven)	6,000
8. Pump-house, artesian wells, reservoir, etc	7,000
9. Piles	2,000
10. Installation	6,000
11. Electric lines	5,000
12. Office and engineering expenses and unforeseen	13,000
	120,000

Cost of Manufacture

Per ton of air-dried fuel with 30 per cent moisture content:—

	Total Kronen	Per ton Kronen
Wages—9 men for 1,000 hours at 1 krone per hour	9,000	0·57
Superintendent and foreman, all year	9,600	0·60
Power—10 kw. per ton at 0·10 krone per kw. hr		1·00
Piles—driving, pulling out and replacements	2,000	0·13
Upkeep and oil	6,000	0·40
Interest and depreciation 15 per cent on 120,000 kronen	18,000	1·13
		3·83
Turning (by contract)		0·65
Harvesting (by contract)		2·40
		6·88

To this must be added:—

(a) Interest or rent of drying-grounds and upkeep of same, estimated	0·25
(b) Cost of the raw peat, which is in Denmark, about	1·00
(c) Royalties	2·00
Estimated production cost per ton	10·13

Advantages and Disadvantages

Several advantages are claimed for the hydro-peat process:—

(1) It is specially adapted for use in bogs containing many roots and stumps.

(2) It permits operation on a large scale on wet bogs, not capable of supporting heavy machines.

(3) The excavation of a large area is centralized at one point on the bog.

(4) The method of transportation of peat through pipes to the drying-field is favourable to large-scale production.

(5) All of the apparatus is simple in design and construction, reliable and easy to operate, and that repairs and cost of maintenance are small, i.e., relative to production.

(6) Skilled workmen are not required.

(7) The number of labourers required to produce a given quantity of fuel is small as compared with other processes.

(8) The drying-ground can be located on firm soil outside the limits of the bog, and wet peat can, therefore, be spread several times during a season. On a drying-ground composed of sandy soil covered with grass, it is claimed that the peat is ready for harvesting in four weeks.

In connexion with these claims it is necessary to bear in mind that the hydro-peat system of hydraulic excavation can be successfully employed only on bogs where very large quantities of water are available, and where a sufficient area of level ground with a sandy surface soil of a depth of 4 inches covered with grass, and suitable to provide a drying-area, is located close to the bog.

WATER SUPPLY

Since water for the hydraulic excavation of the peat must be constantly used in very large quantities, a practically unlimited water supply is a fundamental requirement for the carrying on of operation.

Assuming that the water content of the bog is 90 per cent, and that the excavated peat led through the pipes contains 96 per cent water, the excess water which must be added for hydraulicing and transportation in pipes amounts to 3,000 Imperial gallons per ton of dry peat content. For the production of 200 tons of peat fuel per day, 600,000 Imperial gallons of additional water is required. For a season of 100 days, 60,000,000 Imperial gallons would be thus required, or sufficient water to fill a reservoir 8 feet deep and with an area of 23 acres. It is interesting to compare with this the area of the bog which must be excavated to a depth of 8 feet, for the recovery of 200 tons of dry peat per day for a season of 100 days, viz., about 16 acres. This large amount of excess water which is conveyed away from the bog to the drying-area in intimate association with the peat itself, does not become again available for use in the process, and fresh supplies of water must be constantly obtained. At the Lundergaard hydro-peat plant provision for supplying this excess water has been made by sinking shallow artesian wells, abundant water being obtained by sinking 4-inch pipes into the bog itself.

Climatic and other conditions in Canada, however, differ widely from those found in Denmark, and there are comparatively few localities where an adequate water supply can be obtained by the above means. During the operations carried on by the Committee at Alfred, for example, trouble was experienced at some seasons in obtaining from the excavated portion of the bog, sufficient water for feeding the boilers. In order to augment the water supply, pipes were driven into the bog, in one instance to a depth of 70 feet, but the additional supply obtained by this means was negligible. The factor of water supply alone would, therefore, render the hydro-peat method inapplicable to a large proportion of Canadian bogs.

DRYING-AREA

It will be readily understood that the surface of the bog itself cannot be utilized as a drying-area for operation by the hydro-peat method. Since the excavated peat is delivered through pipes to the drying-surface, and the thin liquid pulp containing approximately 96 per cent of water forms intimate contact with the surface, if this material is deposited on the surface of the bog its moisture content will not become less than that of the bog itself. At many of the Canadian bogs best adapted for the production of peat fuel, drying-areas suitable to the process are not available. Where a drying-ground can be obtained in such proximity to the bog as to permit economic transportation to it by pipe line from the bog, the additional investment for the purchase of the large area required, and the cost of its preparation and maintenance are serious factors in the financial success of the undertaking. The cost per acre of land suitable for the purpose would be very much higher than that of the bog itself, and unlike the bog it is not available as a source of material for the production of fuel. The utilization of the surface of the bog itself constitutes, therefore, a decided economic advantage in favour of processes in which it is practicable.

NUMBER OF SPREADS PER SEASON

The number of times that the drying-area may be spread with peat during the season is problematical. With the method recommended by the Peat Committee, two spreads per season is considered to be a conservative estimate. Although under favourable weather and operating conditions, a third spreading may be successfully harvested, this cannot be safely reckoned upon as a basis of estimation of financial requirements and returns. With either method the number of spreads which can be made depends upon the amount of rainfall during the season, and therefore the minimum number of spreads which can be obtained during a comparatively wet season should be used as a basis of estimation of the area of drying-ground required for the desired production.

CAPITAL REQUIREMENTS AND COST OF MANUFACTURE

The estimates of cost shown on a preceding page do not indicate that the hydro-peat process, where it could be employed, would have any economic advantage over the method of manufacture followed by the Peat Committee at Alfred.

A plant with an annual production capacity of 16,000 tons is estimated to cost 120,000 kronen, which at par of exchange is equivalent to $32,160. Owing to the higher cost of fabrication, in Canada, the cost of a similar plant here would be from $40,000 to $45,000. As compared with this a plant of the type developed by the Peat Committee, with an annual production capacity of 20,000 tons is estimated to cost $35,000. In the latter case the productive capacity is based on a 20-hour day, since all operations are automatic and experience has shown that the plant can be operated satisfactorily at night. Practical difficulties make it doubtful whether the operations of the hydro-peat process could be conducted with equal success by artificial light.

Other capital requirements—cost of the bog, power plant, harvesting equipment, transportation facilities, buildings, etc., would be the same for either method of manufacture. The cost of drainage of the bog is saved under the hydro-peat system, but this is offset by the necessity of purchasing and preparation of a large area of land adjacent to the bog to serve as a drying-ground.

The principal items entering into cost of manufacture are (1) labour, (2) power, (3) cost of raw material, (4) repairs and supplies, and (5) overhead charges. Items (2), (3), and (5) would be practically the same for both systems. Under the hydro-peat method of operating four men are employed in excavating, and four in spreading, and, in addition, the cutting of the spread peat into blocks is done by the superintendent or foreman. The plant developed by the Committee requires six men to perform the same operations. At least part time of a mechanic would also be required under either system. Operations subsequent to the spreading of the raw peat on the drying-area, including turning and harvesting are common to both. Cost of repairs would probably be somewhat less under the hydro-peat method, but this is a comparatively small item in any case.

OTHER CONSIDERATIONS

Regarding the claim made as to the advantage of transportation by pipe line, it must be borne in mind that the raw material which must be transported by pipe line for a considerable distance to high land outside the limits of the bog has seventeen times the volume and weight of the fuel recovered. Under the system developed at Alfred, raw material with only seven times the volume and weight is deposited directly on a belt and deposited on the bog adjacent to the excavator. The difference in cost of the subsequent transportation of the finished product is not a matter of serious importance. Where other conditions are favourable to its employment the hydro-peat method apparently possesses distinct advantages over other processes for the working of bogs which are full of roots and stumps, or which cannot be economically drained. Hydraulic excavation also permits practically complete recovery of the peat contents of the bog. The quality of air-dried peat fuel depends materially on the degree of maceration of the raw peat effected. The results obtained at Alfred fully demonstrate that maceration can be very efficiently performed and a high quality of fuel obtained by the use of machines of the swing hammer, shredder type.

OTHER ATTEMPTS MADE BY WET CARBONIZING LIMITED TO RENDER THEIR PROCESS FOR MANUFACTURING PEAT FUEL, COMMERCIAL OR ECONOMIC

Towards the conclusion of the large-scale operations of the Wet Carbonizing, Limited, at Dumfries, Scotland, considerable work was done in developing a special type of drier according to the designs of Söderlund. In this drier an attempt was made to utilize the latent heat of the steam used for drying, or a portion thereof. The method employed was as follows: A drier was constructed composed of an inner revolving drum surrounded by a fixed drum of considerably larger diameter. Live steam was admitted to the inner revolving drum and the peat to be dried was spread in a thin layer on the surface of this drum. The heat of the steam in the inner drum was conducted through its shell to the thin layer of peat spread on its outer surface, thereby evaporating the water content of the peat. For every pound of water converted into steam "at practically atmospheric pressure" in the annular space formed by the two drums, one pound of steam was condensed in the inner drum. In order to render available the latent heat of the steam formed by the evaporation of the water content of the peat, this steam was withdrawn from the annular space by means of a thermo-compressor which also compressed the steam thereby raising its temperature and pressure. It was then turned back into the inner drum. Although in theory a considerable saving in heat would be obtained by this means, in practice it failed to yield the expected results, and this method was consequently abandoned after having had a thorough trial.

PECO LIMITED

At the conclusion of the efforts to establish the wet-carbonizing process on an economic basis, and which resulted in the dismantling of the elaborate plant installed at the expense of the British Government, attention was directed to other methods for dehydrating peat and converting it into a marketable fuel. Experimental work, undertaken by those interested in the efforts to perfect the wet-carbonizing process, led to results which were considered of sufficient promise to warrant the formation of a new company to develop a process based on the results obtained in the laboratory and to eventually establish it on a commercial scale. The company exploiting this new process is known as Peco Limited. The objective sought in submitting raw peat to heat treatment in the presence of water was the destruction of the colloidal properties of peat which it was realized prevent the expulsion of the water content by pressure. The new method aims at the removal of the true colloidal matter of peat rather than its destruction. According to this method the raw peat is, as heretofore, dredged and transmitted to the plant through a pipe line, the water content of the peat, as delivered at the plant, being in the neighbourhood of 95 to 96 per cent. The peat is then delivered to a specially designed washing apparatus in which more water is added, and the mixture is briskly agitated by means of revolving paddles. During the operation the larger proportion of the true colloidal matter (gels) is washed out.

The liquid mass, having the consistency of muddy water, is then transmitted to the top of sloping screens of fine wire mesh. The water containing the gels and a certain quantity of finely divided peat passes through the screen and is collected in troughs, where it is led to settling tanks. The fibrous material, now freed from the gels, remains on the upper side of the screen, where it passes down by gravity to a trough fitted with a spiral conveyer, which carries it to the hopper of an especially constructed press.

The press consists of two drums in a horizontal plane with vertical axes. Around each of these drums are placed several continuous steel bands which are of the same width as the faces of the drums, but of varying lengths, so as to nest one within another around the drums.

When pressure produced by springs and screws is applied, the bands move with the drums which are rotated in opposite directions. The washed peat containing over 90 per cent water is fed through a hopper into the spaces between the steel bands and as the drums are turned and the spaces between the bands decreased, water is pressed out of the peat. When the bands reach the point where the greatest pressure is exerted the pressing is complete. The pressed peat, in the form of thin flakes, adheres to the surface of the bands, and is removed by a scraper. By means of this press the moisture content of the peat is reduced to 70 per cent. Before briquetting, which is the final stage in the process, the moisture content must be further reduced from 70 per cent to about 15 per cent by drying in artificial driers.

At the time of the writer's visit to the experimental plant in June, 1924, a test was being conducted by Swedish engineers representing interested parties in Sweden, but operations up to this time had not been carried out on a sufficiently large scale to determine costs.

Although the treatment of the peat in the above manner enables the water content of the washed peat to be reduced to approximately 70 per cent, the stages through which the raw peat containing only about 4 per cent solid substance must pass are many and expensive. But there are very serious obstacles even to the technical solution of the problems involved, for example, a considerable portion of the combustible matter of the raw peat is carried away in the wash water. This combustible substance is composed of the gels and the fine peat particles, the amount of which is very considerable. In order to recover a part or the major portion of this combustible substance, the water is delivered to large settling-tanks where, with the aid of a chemical to hasten precipitation, it is hoped that the solid substance will settle out in a few hours. The water, more or less freed from the peat substance, is then decanted, and returned for use in the process, and the slimes containing approximately 95 to 96 per cent moisture are delivered through a pipe line to an especially prepared drying-field where they are allowed to accumulate to a depth of 7 inches up to 12 inches or more. Drying takes place in a manner similar to that employed in the manufacture of hydro-peat.

This is a general description of the stages it is proposed to follow in case attempts are made to establish this process on a commercial scale, but, it is the writer's opinion that even though the various stages in the above process are carried out with the utmost efficiency, the chances for success are very remote, since a low-grade fuel like peat cannot stand

the expense of many handlings, and in addition the expenditure of heat for drying. The process is ingenious and interesting, and a large amount of valuable work has been performed in connexion with its development, but the process like its predecessor, the wet-carbonizing process, will probably not prove of any serious assistance in the establishment of a peat industry.

PEAT POWER PLANT AT TORRE DEL LAGO

A peat manufacturing and power plant, for the purpose of generating power to operate a portion of the Italian State Railway, has been erected at Torre del Lago, Italy. The bog surrounding the lake from which peat is obtained for use in the gas producers is submerged during part of each year, and its winning and preparation as a fuel suitable for burning in gas producers, presents many difficulties. To overcome these, novel and interesting methods have been devised. In the summer the surface of the peat bog is practically level with the water, while in the winter it is covered with several inches of water. Peat-winning, however, is carried on throughout the entire year. The method employed, therefore, is that which applies to winter conditions.

Several dredges are employed which work into the bog from the lake at different points, first of all cutting out canals, the material from which is disposed along the banks forming dykes. When the dykes are sufficiently high to prevent water from the lake entering the enclosed portion, the dredged material is then dumped and spread over the drying-area formed in this manner. When sufficiently dry, the peat is harvested and transported to the plant where it is burned in gas producers. Two hundred and ten men are employed throughout the entire year, and in summer and for a certain portion of the winter, 300 women and boys are employed for harvesting, etc. The cost of the peat per ton laid on the bog is stated to be 10 lira, equivalent to about $1.93 at par of exchange. Laid down at the plant with from 30 to 40 per cent moisture, the cost is said to be 36 lira, equivalent to about $6.94. However, during 1925 it is expected that the average cost per ton laid down at the plant will be between 25 and 26 lira, or about $4.92.

Power Plant

The power plant consists of gas-fired steam boilers and steam turbines capable of generating 10,000 kw. The gas for the boilers is supplied by six Mond producers, especially designed for burning peat. One producer is held in reserve, five producers having ample capacity to supply the required quantity of gas to generate 10,000 kw. The producers are of the by-product recovery type, the nitrogen content of the peat being sufficiently high to permit the recovery of ammonia and the manufacture of ammonium sulphate to be carried on profitably. The average ash content of the peat used in the producers is approximately 25 per cent.

Although the plant as at present laid out is capable of generating 10,000 kw. continuously, only a portion of this was being generated during July, 1924, since the electrification of the railway to be served by this power was not then complete. The plant including that for manufacturing the fuel, as well as that for generating power, has not been operating for sufficient time to obtain reliable data regarding costs.

CHAPTER VI

THE AIR-DRYING PROCESS

GENERAL FEATURES

Peat as it occurs in bogs, contains from 90 to 95 per cent of water, and only one-twentieth to one-tenth of its entire weight is recoverable as absolutely dry substance. By drainage, a portion of the water may be removed, and the water content reduced to 85 to 90 per cent.

In order to produce an economic fuel from peat its water content must be further reduced to 25 to 30 per cent. The only means by which this can be accomplished are:

(1) Air-drying.
(2) Evaporating the water by artificial heat.
(3) Removing the water by mechanical means.
(4) Electrical osmosis.

The amount of dry substance contained in raw peat, if consumed, is ordinarily, insufficient to yield the heat required for production of the same amount of dry peat. Similarly the burning of a given amount of peat fuel containing 10, 20, or 30 per cent moisture will not effect the evaporation necessary to produce a like amount of fuel with 10, 20, or 30 per cent moisture content.

The effectiveness of pressure or other mechanical means to expel water from peat is strictly limited by the colloidal properties of the material. The more thoroughly the peat is decomposed or humified, and therefore the greater its suitability for fuel production, the more marked do these properties become, and the lower is the degree of effectiveness of any means for mechanical expulsion of the water contained.

Attempts to facilitate removal of water by destruction of the colloidal properties of the raw peat have hitherto failed to produce commercial results. Heat and electrical treatments have alike been unsuccessful.

No economic method of drying by artificially generated heat is yet available. No process depending upon mechanical pressure for expulsion of the water has attained commercial success, nor has any combination of these methods up to the present time proved economic. In every case where peat fuel is produced commercially at the present time the product has been air-dried, and the only processes which have attained commercial success are those which are solely dependent upon air-drying for the evaporation of the water from the raw peat.

In the following outline of the air-drying process it is assumed that mechanical excavators are to be employed and machines are to be used for the various subsequent operations wherever it may be practicable. Where hand-digging is resorted to the procedure will differ in some details from that described, but, on account of the high cost of manual labour, such a method is inapplicable in Canada, and is therefore not dealt with. The various steps as carried out in the operation of the Peat Committee at Alfred, Ontario, are described.

STEPS IN THE PROCESS

(1) Clearing and drainage of bog.
(2) Excavation of raw peat from the bog.
(3) Pulping or maceration.
(4) Transportation to drying-field.
(5) Spreading on drying-area.
(6) Cutting into blocks.
(7) Turning partly dried blocks.
(8) Collecting the finished fuel.
(9) Transportation to railway cars or storage.

Clearing and Drainage of the Bog

The working-area must be cleared of trees and the larger shrubs. Where the surface of the bog is to be used as a drying-area, the presence of some of the smaller heaths is rather an advantage than otherwise, since, when pressed down by the spreader, they form a cushion which promotes air-circulation beneath the layer of peat and prevents absorption of water by capillary attraction from below. The effect of drainage of a bog may be to reduce the water content by only 5 or 6 per cent. This is more important than it may seem at first glance, since if the water content of peat in the bog is 92 per cent and this is reduced by draining to 86 per cent, the weight of material to be excavated and handled is only about one-half what it was before.

The draining of each bog presents problems peculiar to that bog, and location of the necessary ditches depends largely on the working-area and the machinery to be employed. Some general principles may however be stated. A large number of shallow ditches are preferable to fewer deep ones, since the influence of a drain in a bog extends only for a short distance from the side-walls of the ditch. Ditches at the outset should be shallow, lowering the water-level only enough to produce a sufficiently firm working-surface, but may be deepened from year to year as the bog settles. Since it is undesirable that frost should penetrate deeply into the bog, dams should be placed to keep the water-level high in winter. If practicable, drainage should be effected one or two seasons before actual manufacturing operations are undertaken in order that a comparatively firm surface may be obtained to carry the machines and for transporting the peat fuel when manufactured. In laying out and planning the drainage of a working-area for the manufacture of peat fuel the services of a properly qualified engineer are indispensable. Over-drainage is to be avoided, since it unnecessarily increases the risk of loss and injury to the bog surface by fire.

Not all bogs are capable of natural drainage. Those of the built-up type, the so-called high bogs, which show a uniformity of structure, or the presence from bottom to top of the remains of such plants as always grow near or slightly above the ground-water level, can be drained as deep as such structure is found. Some deposits, however, lie chiefly below the water-level, and can be drained only at great expense. In such cases the drying-areas must be located on higher ground adjacent to the bog.

Excavation of the Raw Peat

The raw peat is raised from the bog by a mechanical excavator provided with steel buckets on an endless chain which scrape the sloping wall of a trench from bottom to top and deposit the excavated peat in a hopper. Digging is automatic and continuous, the excavating element moving from side to side over a width of about 30 feet, and making a cut about 4 inches thick for the depth of the bog up to a limit of about 10 feet. The excavating element is carried on a platform supported on caterpillars which travel over the surface of the bog. The greatest obstacle in the way of excavation of peat by machines is the frequent presence in bogs of undecayed roots, trunks or stumps of trees, which are found firmly embedded in the peat at various depths, and which seriously interfere with the operation of most types of excavators commonly employed for other materials. By such a mechanism as described the smaller roots are broken up and readily removed, while the larger roots and tree trunks are gradually uncovered and their removal facilitated. When roots are numerous, the services of a man are required at the face of the trench, to prevent clogging of the machine. Breaking up of the roots is further effected by a series of heavy cutting knives attached to the bucket-carrying element.

A very important advantage gained by the employment of such an excavator is the even and thorough mixing of peat from all layers of the bog from bottom to top, whereby uniformity of quality of the fuel produced is obtained. Since peat exists in stratified layers, and the deeper layers are usually the best humified, such methods of excavation as harrowing the surface and removing the air-dried material, as formerly practised at several bogs in Canada, are unsatisfactory. Where a bog cannot be sufficiently drained to permit working of machines on the surface, it may be necessary to utilize some form of dredge.

Pulping or Maceration

The excavated peat containing 85 to 90 per cent of water is fed into a macerator or pulping machine which breaks up the roots, disintegrates the fibres and reduces the entire mass to a thick slop or soft pulp. Great importance attaches to this stage of the process, as the ultimate density and firmness of the completed fuel depends very largely upon the degree of efficiency obtained in maceration. The strong shrinkage produced by drying well-humified peat is due to the presence of large quantities of peat humus, which is of a colloidal nature, that is to say, consists of peat, in a very finely divided condition, intimately associated with large quantities of water. The existence of partly undecomposed fibrous plant structures tends to hinder aggregation of the finer particles of peat and this produces a more or less porous product. The enclosed air spaces increase hygroscopicity and bulk, and tend to promote disintegration of the fuel block. Ordinary hand-cut peat for this reason is a very inferior fuel, unless the peat is extremely well humified and entirely free from fibrous structure.

Several machines have been developed and widely employed in Europe for pulping peat. The Anrep macerator, used during the earlier operations at Alfred, depends on the action of a series of rotating knives intermeshed with stationary knives. This macerator proved fairly effective in the absence of roots. When, however, the peat contained large quantities of roots and fibrous materials trouble was experienced through clogging of the machine and this caused frequent breakages.

A machine of the hammer mill type, installed later, proved highly efficient. Not only were delays due to clogging and breakages avoided, but the resultant fuel was of superior quality. On the other hand the consumption of power was materially increased.

Transportation to Drying-field

Various methods of conveying the peat slop to the drying-field have been employed. Transportation in buckets travelling along overhead cableways of a portable Telfer system was experimentally tried out on the Alfred bog in 1913, but did not prove entirely satisfactory.

Dump cars drawn by endless cable over light tracks laid in the form of a rectangle, the inner side of which is moved when each row across the drying-area is completed, were employed in the operation of Plant No. 1 at Alfred. Loss of time due to moving of rails and accidents to cars proved to be so great as to seriously affect the economic success of the entire undertaking.

Eventually, satisfactory results were obtained by employing a portable belt conveyer supported on caterpillars and moving laterally, a distance of 12 to 15 feet, as each row was completed. Since the excavator advanced only about 4 inches at a time, the necessary flexibility to secure harmony of operations was obtained by means of delivery into a trough about 18 feet in length containing a spiral conveyer to move the peat to the point of discharge on the belt.

Spreading on the Drying-area

In the matter of transportation of the peat to and spreading it on the drying-field, a different practice has been developed at Alfred from that followed in Europe.

The most recent European machines provide for moulding the peat into blocks as it comes from the macerator, and transporting the moulded blocks to and dumping them on the drying-area. This method has the disadvantage that the wet peat blocks when dumped are more or less distorted. When the peat is required for industrial use or power production at the bog the shape of the blocks is of comparatively slight importance; but if the peat is to be transported and sold for domestic use, regularity in shape and size not only improves the appearance of the fuel, but tends to minimize loss from waste in handling.

At the Alfred plant the peat slop is delivered from the belt to a spreading-machine carried on caterpillars. This moves back and forth alongside the belt, and deposits it in evenly moulded ribbon-like strips 12 feet wide, and of such thickness as may be desired; the thickness of the spread material

being regulated by the depth of the spreader outlet opening. The advantages of this method of spreading are important. The standard spreaders used in Europe for handling peat slop, e.g., the Jakobson field-press, dump it on the surface of the drying-area, and merely level the top of the peat mass. In this way they produce a smooth upper surface, but the under surface follows the irregularities of the bog, so that in passing over depressions peat is deposited sometimes to a depth of as much as 12 inches, while at other points it is too thin. The result is very unequal drying, and in some cases loss of fuel through over-drying in thin spots before the bulk of the peat is ready for harvesting operations. Moreover, the pressure exerted in levelling the upper surface tends to force the peat mass into close contact with the bog surface thereby excluding air, and retarding drying owing to increase of capillary attraction due to such contact. Even in the case of the dumping of moulded blocks of wet peat, their impact on the bog surface has a similar tendency. By the method developed and employed at Alfred, not only are fuel blocks of regular shape and uniform thickness obtained, but the peat mass is lightly deposited; the result being better drying conditions and a more uniform product.

A further advantage is the ease with which the thickness of the peat layer can be regulated according to the character of the peat slop and the general drying conditions prevailing. Thus in the early part of the summer when drying proceeds more rapidly, the peat can, with advantage, be spread more thickly, while in the later part of the season a thinner layer can be deposited.

Cutting into Blocks

Formation of the peat into blocks of regular shape and size is effected as it is laid down on the drying-area by means of knives and disks attached to the spreader, which make transverse and longitudinal cuts at regular intervals.

Turning the Partly Dried Blocks

As the volume of the peat shrinks in drying, cracks open up along the lines of the cuts made in the peat slop, dividing it into blocks of uniform size and shape. Drying thus proceeds freely and shrinkage takes place on five sides of the block. On the under side, which rests on the surface of the drying-area, drying proceeds more slowly and when the upper surfaces have reached a certain degree of firmness, the blocks are turned over. So far, this operation has been performed by hand, the most effective implement for the purpose being an ordinary garden rake.

According to European practice the peat blocks after being turned and further dried are collected in loose open piles, four or five feet in height. This operation is called cubing. The peat remains in these small piles until ready for shipment or storage. Under the climatic conditions existing at Alfred, it has been found practicable to dispense with cubing, excepting in the case of peat lying in depressions or on spots where fire has destroyed the fibrous structure of the surface of the bog. The peat laid on such surfaces may require cubing to ensure its being ready to harvest with the rest of the peat on the drying-area. The quantity of such peat will, however, be small.

Collecting the Finished Fuel

Up to the present time no mechanical appliance has been devised which will successfully pick up the dried peat blocks from the field without the aid of manual labour. A peat harvester, which has been employed at Alfred, however, considerably reduces the manual labour required. It consists of a light steel channel, 18 inches wide, 9 inches deep, and 60 inches long, carried a few inches above the surface of the bog and supported at each end on small caterpillar elements driven by a gasoline engine. As it is advanced along the field, the fuel is thrown into it by men with coke forks. Suitably spaced cleats on a moving endless chain convey the peat to the end of the channel, elevate it and deposit it in cars on a portable field track.

Transportation of the Finished Product

Portable field tracks are laid on the drying-area as required for operation of the harvester. The small cars as loaded are delivered to the main track, and empties brought in for filling, by a light gasoline tractor. The main tracks over the bog and to the point of shipment or storage are permanently laid with rails of sufficient weight to enable the employment of a small gasoline locomotive hauling 8 to 10 cars carrying 2 to $2\frac{1}{2}$ tons each.

PART II

CHAPTER VII

INVESTIGATIONS CONDUCTED BY PEAT COMMITTEE

THE ALFRED BOG

LOCATION AND AREA

After careful examination of several proposed locations, the Alfred bog, situated in the townships of Alfred and Caledonia in the county of Prescott, Ontario, about 40 miles from Ottawa, and 70 miles from Montreal, was selected as the site of the operations to be carried on by the Committee. It is directly on the line of, and a portion of it is traversed by the short line of the Canadian Pacific railway between Montreal and Ottawa. The total area is approximately 6,800 acres; but only 400 to 500 acres lying north of the railway tracks were utilized for the purposes of the investigation. (Figure 15.)

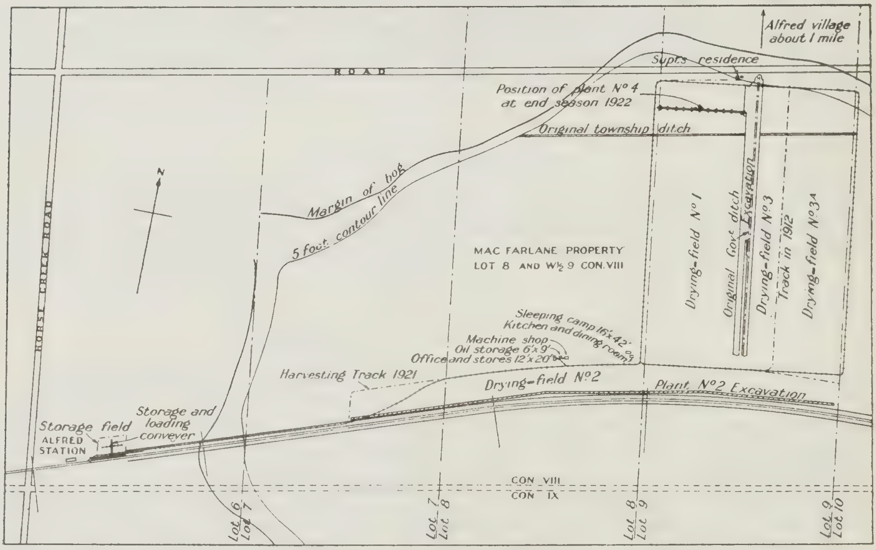


FIGURE 15. Plan of Alfred property

DEPTH AND SURFACE

The section of the bog varies from 8 to 10 feet in depth, which allowing for subsidence due to drainage gives an average working depth of about 7 feet. The area under development is, in its natural state covered fairly uniformly with the typical small shrubs, heaths and moss which ultimately make an excellent drying-field, and is comparatively level and free from holes.

DRAINAGE

A good drainage outlet is afforded by a township ditch running across the northerly end of the bog, approximately parallel to the northern boundary and about 600 feet south of it. The working-trench which was excavated during previous operations on the bog crosses this ditch at right angles and serves as a main drain. Shallow cross drains, 200 feet apart, empty into the working-trench completing the main drainage scheme. These were further supplemented by a ditch parallel to the central line of the working-trench at a distance of about 900 feet and connecting the outer ends of the cross ditches. During the course of the operations of the Committee a second working-trench was developed alongside and parallel to the railway. This excavation had an independent outlet to the west side of the bog, and served to drain an additional drying-area.

DRYING-AREA

Due to experimental operations which were conducted on the bog for several years prior to the investigation, a level drying-area and prepared working-face for one machine were already available.

COMPOSITION OF THE PEAT

The peat is principally composed of sphagnum, with admixtures in certain parts of hypnum, Eriophorum, and carex, and is fairly well, though not uniformly humified. In some portions of the area it is free from roots, but other parts contain large numbers of roots and stumps. The floor of the bog is compact blue clay.

QUALITY AND HEATING VALUE

The peat is of good fuel quality with an average fixed carbon content of about 25 per cent and volatile matter 68·5 per cent, calculated on dry basis, and an average calorific value of about 9,000 B.T.U. The ash content varies from 5 to 7 per cent.

RAILWAY AND STORAGE FACILITIES

Although the Canadian Pacific railway traverses the property, it was necessary, owing to the insecure foundation afforded by the bog surface, to locate the railway siding for shipping at Alfred station, distant a little over a mile from the drying-field. This siding was connected with the operating area by a light, narrow guage track, laid for a portion of the distance, on the railway right of way.

Storage facilities were also provided adjacent to the railway siding, an acre of land being leased for the purpose.

A plan of the property used by the Peat Committee showing locations of excavations, drying-fields, and buildings, is shown as Figure 15.

CONSIDERATIONS AFFECTING THE SELECTION OF PLANTS FOR EXPERIMENTATION

As a result of an exhaustive survey of all methods and processes devised and tried out either on a technical or commercial scale, the Peat Committee were convinced that the air-dried machine-peat process was the only one that could be employed commercially for the manufacture of peat fuel.

Process Demonstrated by Mines Branch

The process had been demonstrated on a comparatively small scale in 1910-11 by the Mines Branch of the Department of Mines. At the close of two seasons' operation of a small plant, during which period several thousand tons of peat fuel were manufactured, a report was issued setting forth the results obtained and stating that a fuel, with even such a plant as then employed, could be manufactured at a cost which would permit it to compete with anthracite coal at the prices then prevailing.

At the same time, owing to the short operating season, it was recognized that in order to ensure success of any undertaking involving extensive capital investment, every possible economy would have to be introduced. The peat-manufacturing plants, then in operation, in Europe, all produced air-dried machine-peat and, moreover, the process was almost entirely carried out by manual labour. Owing to the plentiful supply of cheap labour available in European countries there was slight inducement to inventors to make any material improvements in the process, so far as introducing labour-saving machinery was concerned, and what was probably of as great importance, coal could be obtained in abundance and at comparatively low prices even in the peat-producing and peat-using countries of Europe. The same conditions, however, could not be said to obtain in Canada where labour wages were higher and at a time when an upward tendency in the rate of wages was then evident. The Mines Branch recognized that no process or method for manufacturing a fuel from a low-grade substance such as peat could be carried out profitably when cost of labour is the controlling factor. It, therefore, recommended that in any plant erected for the manufacture of peat fuel in Canada, every possible labour-saving device be introduced, thus rendering manufacturing operations independent of labour conditions to as great an extent as possible.

Relation of Labour Costs to Types of Machines Employed

The Peat Committee was confronted with this problem to a much greater degree in 1918, and it recognized soon after its appointment and organization, that the number of labourers on a plant would have to be reduced to a much greater extent than that contemplated by the Mines Branch in 1911.

Not only had the cost of even unskilled labour mounted to unprecedented heights—but the cost of the machinery required for carrying out the manufacture of peat fuel had more than doubled—largely due to war conditions. The Committee was consequently governed in its choice of peat machines by the possibilities offered by new designs for reducing labour costs.

The peat plant operated by the Department of Mines in 1910-11 was provided with a power-driven macerator, an elevator for conveying the raw peat dug by manual labour to the macerator, and a power-driven cable for hauling small dump cars from peat machine to spreading-field. All other operations were performed by manual labour the cost of which was excessive for the small output obtained.

In 1912, after the Alfred peat bog and plant were sold to private parties, attempts were made to construct a peat machine equipped with many labour-saving devices such as a mechanical excavator, a mechanically-operated conveying system for transporting pulped peat to the drying-field and a mechanically-operated machine for spreading and cutting the pulped peat into blocks on the drying-field. The entire plant, however, including conveyer system, still required to be moved ahead by manual labour at the completion of the laying of a row of pulped peat. The capacity of the plant was very considerably increased and this, together with the reduction in number of labourers required, materially reduced the cost per ton of manufactured peat.

The outbreak of the war in 1914 prevented the completion of development work and the operation of the machine on a strictly commercial basis. But sufficient work was performed to demonstrate conclusively that certain of the improvements in design were in the right direction; that the design in some respects was fundamentally incorrect and that the estimated capacity could not possibly be maintained throughout a working season.

The results of this attempt, and those which were being made at about the same time in Europe, to introduce labour-saving devices in peat machines, guided to a large extent the Peat Committee and its engineer in the design of the two machines which it adopted.

The general design of the Anrep plant, hereafter designated as Plant No. 1, was materially altered in one respect, viz.: the placing of the platform which carried the excavator element, pulverizer or pulper, steam-power plant and other machinery on caterpillar elements. The excavator also embodied certain marked improvements, which will be described later, but was in other respects substantially the same as that employed in 1912-1914. The conveying system adopted was similar to that employed with the small plant operated by the Mines Branch in 1910-11.

The maximum capacity at the lowest possible cost per ton as regards both labour costs and the overhead due to capital investment, depreciation, etc., was the objective kept in mind in designing the new machines. But the maximum capacity which could be obtained was limited by the macerator available and the maximum permissible weight of plant including power equipment. The maximum hourly output could not possibly be maintained throughout even a portion of the working season, and this fact produced considerable confusion concerning the probable production of peat fuel per entire season. Maximum capacity and average hourly capacity throughout an entire working season bear a very peculiar relation to each other. The former may under perfect conditions be attained for short periods, but the latter is and must be calculated for 1,000 hours irrespective of shutdowns due to rain, breakages, and other causes.

In order, therefore, to maintain a reasonably high average hourly output throughout a season of 1,000 hours, the plant must be capable of maintaining a much higher average hourly production when actually running—and this cannot in any case reach or even nearly approach the maximum hourly production possible, since a reasonable factor of safety must always be allowed in fixing speed of operation. If it is desired to design a peat plant to produce, e.g. 10,000 tons of standard peat fuel per season of 1,000 hours, then the average hourly production of saleable peat fuel, for the entire season of 1,000 hours must be 10 tons. To attain this hourly average, the actual operating capacity of the plant might have to be 20 tons or more per hour when shutdowns, loss of the fuel laid on the drying-field which cannot be recovered, and that which is lost as fines when loading cars for shipment, are taken into consideration. The loss in time due to shutdowns, to weather, to repairs, and to other causes was very carefully recorded during the entire investigation, so that data of great value can now be placed at the disposal of anyone desirous of undertaking the manufacture of peat fuel in the provinces of Ontario and Quebec.

The development of the several labour-saving devices necessitated much experimental work in the course of which fundamental weaknesses were disclosed and as far as time and the funds at the disposal of the Peat Committee would permit, corrected. But the final plant constructed and operated still embodied many imperfections, which for lack of time and funds were not eliminated. They were, however, pointed out and the final design of the complete improved plant is included in this report.

PLANTS CONSTRUCTED AND OPERATED

The Committee built and operated three large plants, and designed, constructed and operated for a short period a small plant with an estimated capacity of from 15 to 20 tons standard peat fuel per day of 10 hours. This plant, it is considered, will prove valuable for working the shallow parts of a bog which cannot be worked to advantage with the large machines and for manufacturing on small bogs, peat fuel for farmers, groups of farmers, and small communities.

The following plants were developed and constructed during the five years of investigation:—

1. Anrep plant, (Plant No. 1).
2. Moore plant, (Plant No. 2).
3. Small 3-man peat machine, (Plant No. 3).
4. Combination Anrep-Moore plant, (Plant No. 4).

In addition to the designing and development of the above plants, a large amount of work was accomplished in developing automatic machinery for spreading and cutting the macerated peat as laid on the drying-field and for harvesting the finished fuel and loading this into cars for shipment.

Plants Nos. 1 and 2 after a mechanical tryout were operated during an entire season under average commercial conditions. The results obtained showed conclusively that Plant No. 1 could not be employed for the manufacture of peat commercially and that Plant No. 2 could only be considered

as suitable for commercial operations on exceptionally large bogs on which an excessively long working-face could be developed. But each plant possessed superior features which the Committee were of opinion could be combined to advantage in a new plant. The Anrep excavator, it was found, was far superior to the Moore, and the latter conveying and spreading system was far superior to the Anrep. The capacity of both plants was considerably below that estimated and since effective improvements did not appear feasible, the Committee decided to abandon both plants and construct a new one which would embody the best features of both.

In the design of Plant No. 4 efforts were concentrated on the development of mechanical devices for reducing the number of labourers required in excavating; on the development of a conveying and spreading system capable of performing automatically the operations of transportation, spreading and cutting of the macerated peat on the drying-field; and on the enlargement of the plant to a capacity of 10,000 tons of saleable peat fuel for the season of 1,000 hours with the elimination of structural weaknesses and simplification of the design of the entire plant.

The principal mechanical appliance developed, was the portable belt conveyer. This was the largest belt conveyer ever constructed for use on surfaces such as are met with on bogs. The capacity of the plant was increased by discarding the Anrep macerator and substituting therefor a swing hammer shredder, which up to this time had never been used for pulping peat.

The swing hammer shredder used for experimental purposes was loaned by the Jeffrey Company of Columbus, Ohio. Its capacity when shredding wood and other substances, for which it was specially designed, was well known, but the estimate as to the size of machine that would be required to handle the requisite quantity of peat to produce an hourly average of 10 tons of saleable standard fuel was based on its performance when pulping or shredding other substances of a somewhat similar nature, e.g. kelp. The estimated capacity based on such performance proved incorrect. The power required to drive the hammer mill increased rapidly as the load was increased above a gross production of about 10 tons of fuel per hour. For this particular type and size of mill its calibration showed that it was not economic to attempt to force the output above 10 tons per hour. It was amply demonstrated that for the mechanical maceration and shredding of peat this machine was far superior to any machine heretofore employed. As will be shown later the apparent specific gravity of the finished peat fuel was, as a result of the more thorough maceration of the raw peat received, materially increased over that of the peat manufactured with the Anrep machine. The quality of the fuel was also improved.

Plant No. 4 was assembled from parts of the Anrep plant (No. 1) and the Moore plant (No. 2), the new components being the portable belt conveyer, spreader, and swing hammer shredder. The power available was inadequate and the excavator element and caterpillars were faulty and very heavy. But it was considered that a complete demonstration of the value of the new plant for commercial operation could be made without incurring the expense of constructing an entirely new machine according to the final designs worked out and which will be discussed in detail later.

The Anrep Plant—Plant No. 1

This plant was constructed entirely according to original designs and plans furnished by the late Aleph Anrep of Helsingborg, Sweden, with such modifications as had been shown by previous experimental work to be necessary or desirable. The plant consisted of the excavator, macerator, cable-car system and field-press.

Description

The Anrep excavator and macerator were carried on a triangular platform supported on three caterpillar elements, and were operated by steam supplied by a locomotive boiler and steam engines which were also carried on the same platform. The two main caterpillars were used for driving, and the third and smaller one for steering. One of the large caterpillars was rigidly fixed to the framework of the machine, and the other pivoted on a central axle which, while it kept the caterpillar in line with the direction of travel, permitted it to adapt itself to inequalities in the ground. The steering caterpillar was attached through a ball and socket joint, and had a steering-arm which was operated by hand through a worm mechanism. The platform thus had a three-point support which largely eliminated any tendency to undue strain on the working parts as the machine travelled ahead.

The long side of the framework provided a rail along which the excavating element moved back and forth at an angle to the line of travel of the machine. By arranging the cutting-face on an angle greater than 90 degrees, with the direction of travel of the machine, all the standing walls of the excavation were left on a slope. This permitted the machine to operate close to the edge, and the excavator buckets to make a clean cut the full width of the excavation.

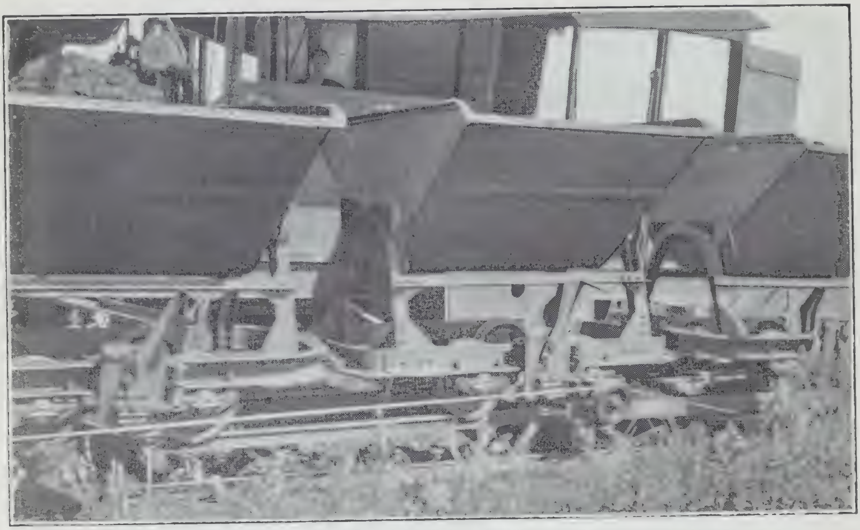
Besides the boiler, the excavating element, and the macerator, the platform supported the necessary conveyers, the engine for operating the excavator and a 6 by 8-inch reversible slide-valve engine which provided power for propelling the machine, and also for the grip wheel operating the cable-car system. There were also a bin for fuel, a tank for feed water, a boiler feed-pump and preheater, and a housing to protect the machinery from the weather.

The peat was dug by a continuous chain and bucket excavator of special design. (Plate XXIII.) The buckets travelled upwards on the under side of the supporting arm and were enclosed within a series of semi-circular or hoop-shaped, steel, cutting knives. This excavating element was hung from a steel framework which travelled backwards and forwards on the rail forming part of the rear member of the main platform. The framework was held from tipping into the excavation by a set of wheels which engaged a guide rail provided for the purpose. The excavator was driven by a 4 by 5-inch twin slide-valve engine geared to run about 400 r.p.m. The mechanism for raising and lowering the excavating arm was driven by a $3\frac{1}{2}$ h.p., reversible Dake engine.

The excavated peat was delivered from the excavator into a trough, running the full width of the machine in which revolved a spiral conveyer, one half right hand, and the other half left hand, so that the excavated material was brought to the centre, where it dropped into a second conveyer which fed it into the macerator. These conveyers were driven by the

Peat Committee's Plant No. 1—excavator

PLATE XXIV



Station car and peat slop cars, Plant No. 1

PLATE XXV

Corner of rectangular field-track

macerator engine. A modified Anrep macerator of the largest capacity available was used for macerating the peat. The barrel of this had been lengthened and additional knives attached to give a capacity greater than that of the standard design. It was direct-connected through a safety coupling to a twin, 7 by 8-inch, simple slide-valve engine, which was governed to run at 275 r.p.m. The macerated peat was delivered into a third spiral conveyer installed on an incline which elevated the pulp so that it was conveniently delivered into the cars of the cable-car system from a spout directly over the track.

Adjacent to the excavator, a rectangle of light, portable steel track (Figure 16) about 800 feet long and 400 feet wide, was laid on the surface of the bog, one of the short ends lying under the spout of the excavator and parallel to its line of travel. A grip wheel installed on the excavator gave motion to an endless cable which was carried through a station car (Plate XXIV) to the inside of the track rectangle, where it was guided to travel a few inches away from the inside rail in position to engage the cable clutches installed on fourteen V-shaped, side-dump, all-steel hopper-cars designed to run on the track. The cable was guided around the corners of the rectangular track by rollers similar to those used in mine haulage (Plate XXV).

Plate XXVI shows the spreading side of the rectangle with steel, dump cars used to transport the peat. These cars hauled by the cable delivered the macerated peat to the spreader. This was a modified Jakobson field-press, which, instead of being hauled by a cable, was self-propelled by a gasoline engine, and was constructed according to the original plant designs prepared in Sweden. The front part of the framework was carried on two rollers which moved independently of each other, so that steering could be effected by the temporary stoppage of either roller as required. A spiral was employed in the hopper to distribute the peat evenly over the spreader box. Long metal strips trailed on edge behind the spreader cut the spread peat longitudinally. The provision made for the steering of the machine proved inadequate, the arrangement for distribution of the peat in the spreader box was ineffective, and the trailing cutting knives gave unsatisfactory results.

Before the season of 1920 an entirely new spreader was designed and constructed (Plate XXVII). Steel was substituted for wood in the general construction, alterations were made to improve the distribution of the peat in the spreader box, and steel disks mounted at regular intervals on an axle were substituted for the cutting knives. Steering was facilitated by a flexible connexion between the tractor and spreading elements of the machine which permitted full movement in any desired direction.

Power for operation of the plant as originally constructed was supplied by a 50 h.p., portable locomotive boiler carried on the excavator platform. This was unsuitable for the purpose and inadequate to meet the requirements of the plant, but was the best which could be obtained at the time owing to the heavy demand due to war activities. Early in the second season of operation it was replaced by a dredge type, Worthington water-tube boiler with 830 square feet of heating surface and with larger grate area and higher combustion chamber than ordinarily used. These special features in design were introduced in order to permit the firing of peat fuel. This also applies to Plant No. 2, description of which follows.

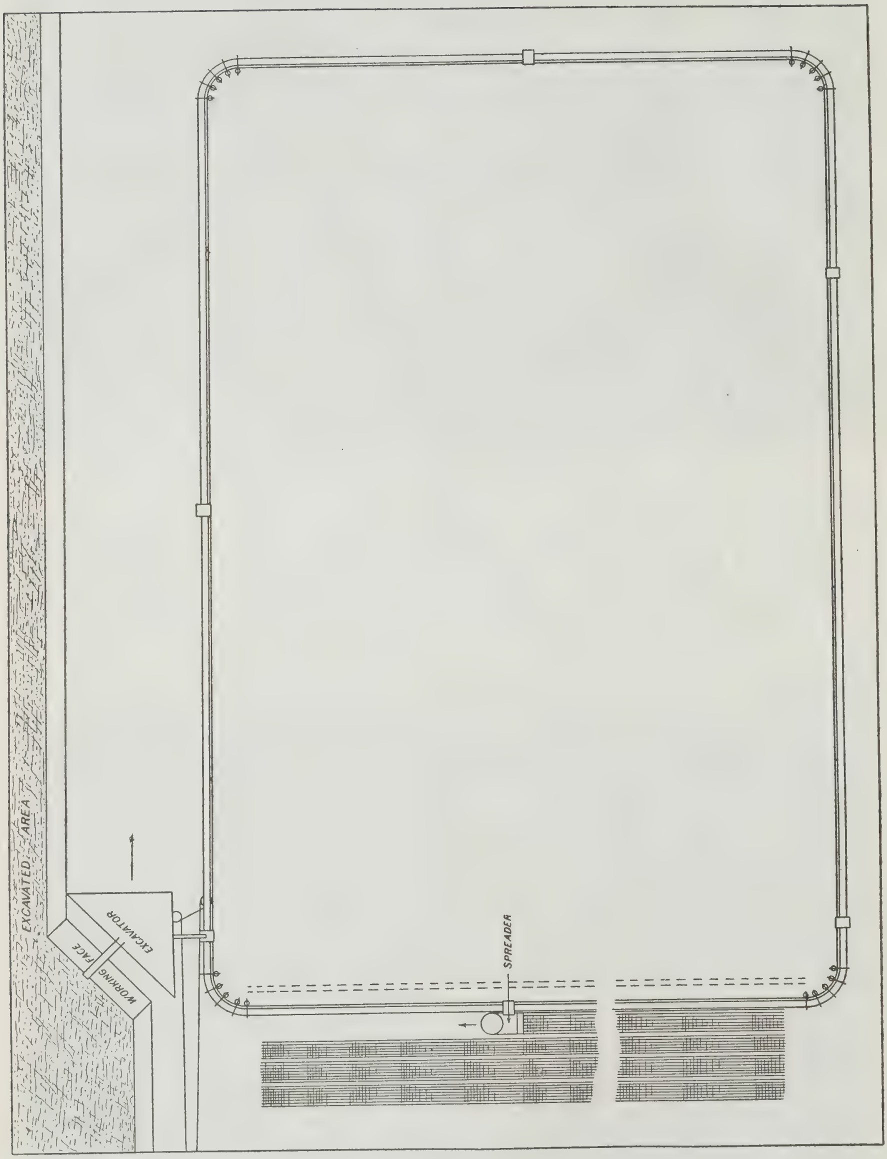
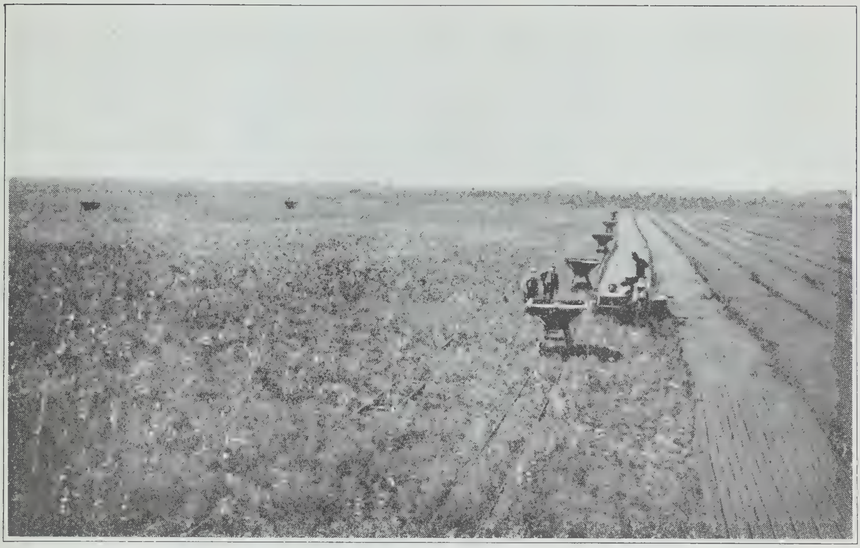


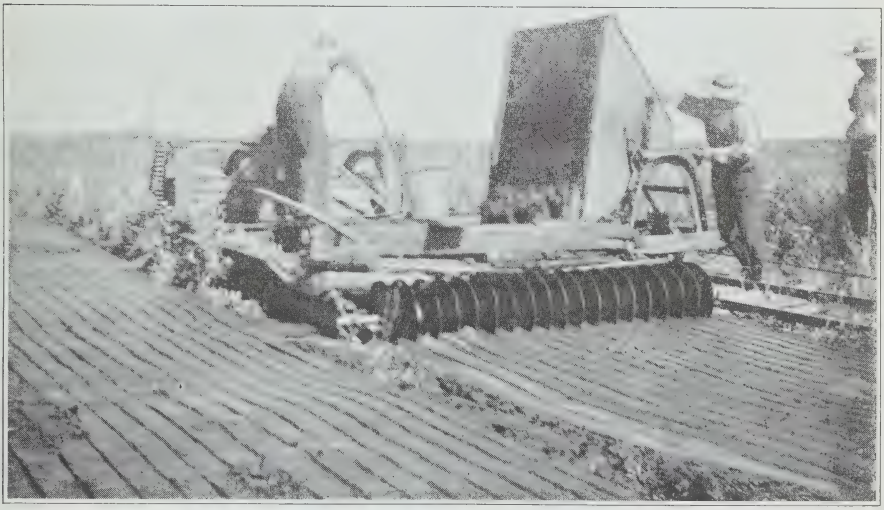
FIGURE 16. Plan of operation of Plant No. 1

PLATE XXVI



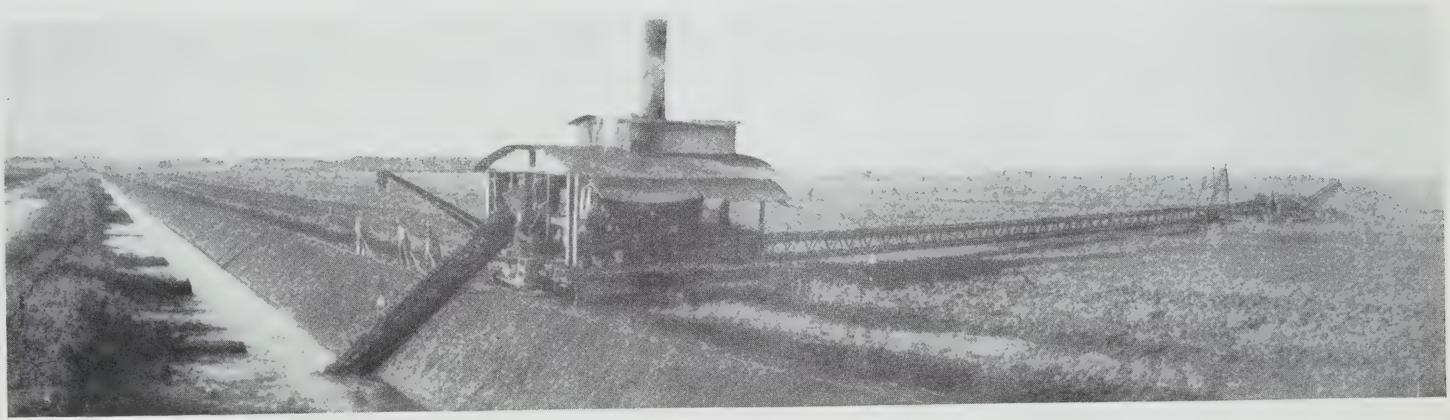
View of spreading side of track rectangle, Plant No. 1

PLATE XXVII



Plant No. 1 spreader, final design

PLATE XXVIII



Peat Committee's Plant No. 2 in operation

The Moore Plant—Plant No. 2

Following the construction of a complete plant with mechanical excavator, according to the Anrep design, the decision was reached to build and try out a plant of an entirely distinct character, and possessing some novel features of design and operation. This plant had been designed by Ernest V. Moore, previous to his employment as engineer to the Committee, but had never been actually constructed.

The advantages claimed for Moore's plant as compared with the Anrep system were: lower plant cost for a given capacity, reduction in number of men required to operate, saving of the time required for moving tracks under the Anrep system, and the possibility of harvesting the fuel with the same machine as was used to lay down the raw peat on the field.

These claims were of so striking a character, and the economies which it was expected would be effected were so marked that after careful consideration the Peat Committee were convinced that the design had sufficient merit to warrant the building of a unit plant for investigation.

The fundamental idea of Plant No. 2 was the combination of a spreading element with an excavating element, so that one machine might be used to excavate, macerate, and lay the peat out to dry. As the design of the machine was worked out it appeared as if the same machine could also be used to harvest the dried fuel.

Description

The complete machine consisted of a platform 18 by 21 feet 6 inches, (Plate XXVIII), carried by two caterpillars each 6 by 15 feet. The excavator element was placed centrally on one side of the platform. This element was 24 feet long and was similar, and similarly supported, to that employed on Plant No. 1.

The platform also carried a 50 h.p., portable locomotive boiler; an enlarged Anrep macerator direct connected to a twin, 7 by 8-inch, vertical slide-valve steam engine; a 4 by 5-inch twin engine connected through a chain drive, clutch and spur gearing to the excavator element; single cylinder, 6 by 8-inch, reversible vertical engine connected by chain drive to the driving mechanism of the caterpillar situated underneath the platform nearest the excavation; a single reversible Dake engine for raising and lowering the excavator arm; an equalizing tank into which the macerated peat was delivered by the macerator, and from which it was fed to a belt conveyer installed on the structural steel frame mentioned below, and the necessary water tank, boiler feed pump, fuel storage bins, etc. (Plan, elevation, and section shown in Figs. 17, 17a, and 17b.)

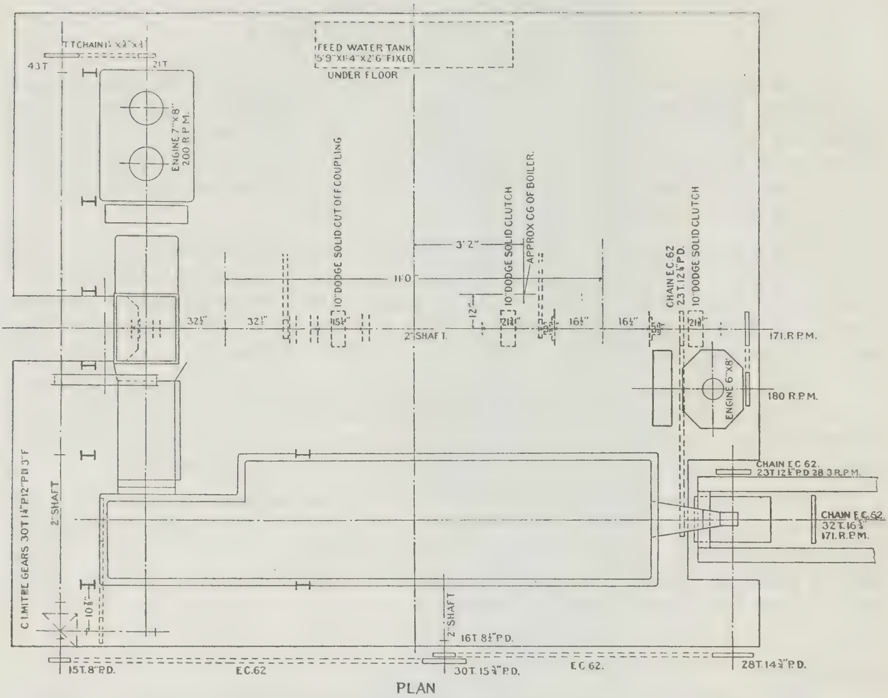


Figure 17. Plan of Plant No. 2

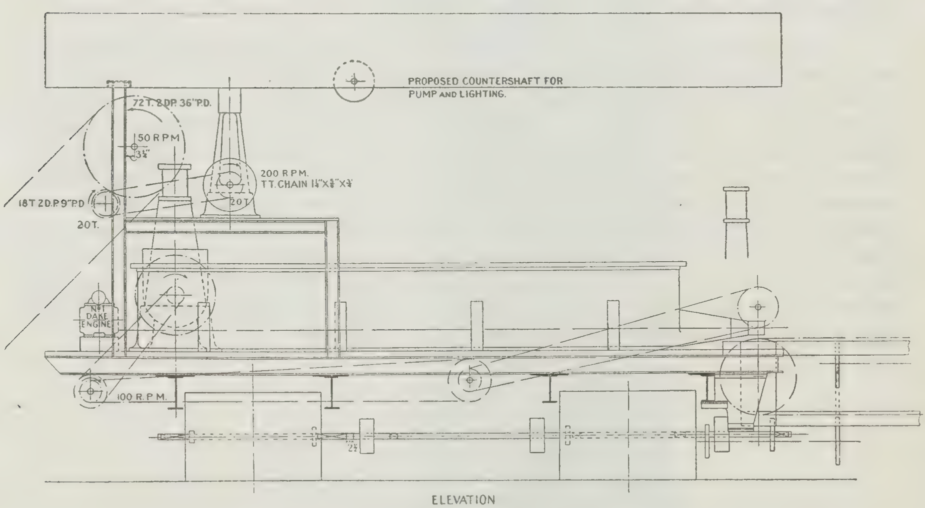
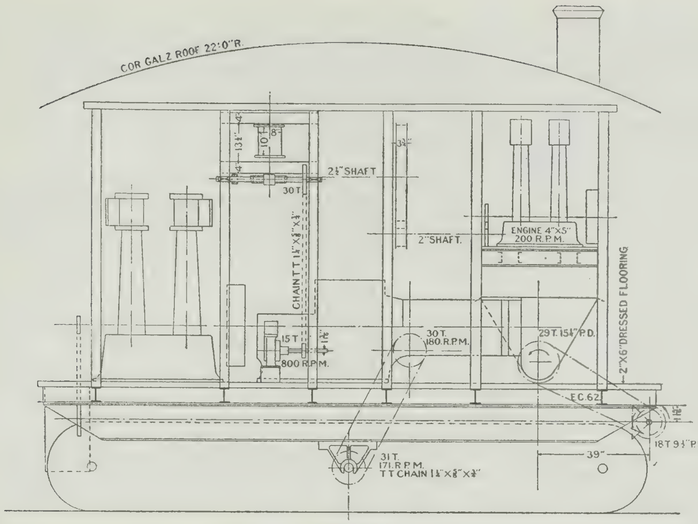


Figure 17a. Elevation of Plant No. 2



SECTION

Figure 17b. Section of Plant No. 2

Directly opposite the excavator on the other side of the platform one end of structural steel bridgework 30 inches square and 180 feet long was flexibly attached. This bridgework extended at right angles to the platform, and was mainly supported by a third caterpillar 6 by 12½ feet (Plate XXIX) situated about 65 feet from its outside end and parallel to the two caterpillars supporting the main platform.

By means of a shaft flexibly connected with the main machine supported on the bridgework and extending almost its entire length, power was furnished to drive the caterpillar under the bridgework at the same speed as the two caterpillars under the platform of the main machine. Power was also supplied through this shaft to operate the spreader.

The belt conveyer (Plate XXXI) was a 14-inch, 5-ply, rubber-covered belt with an additional $\frac{1}{16}$-inch rubber protection on the carrying side. It was supported every 5 feet on the carrying side by ball-bearing, troughed rollers, and on the return side every 10 feet by straight rollers. The belt was driven by a 27-inch pulley at its inside end, at a speed of about 300 feet per minute.

The macerated peat was deflected from the belt conveyer to the hopper of the spreader, which could be attached to the belt conveyer at any desired position (Plate XXXII). The spreader consisted of a box built of sheet steel, 12 feet long by 15 inches square, the ends of which were attached to idler caterpillar elements so adjusted that the box was dragged over the bog surface in contact with but not pressing heavily on the moss surface. The top of the box was covered except for a hopper opening at its centre, and an opening, the full length was left in the rear side at the bottom and arranged so that the depth of the opening could be adjusted from 3 to 6 inches. A standard spiral conveyer, one-half of which was right hand and the other left hand, was placed inside the box.

Both sections of this spiral tapered from the full size of 14 inches at the centre to almost nothing at the end, and the shaft carrying them was rotated by power received from the shaft on the bridgework above mentioned. Attached to the spreader-box was a mechanism for operating cross-cutting knives. These were three in number and consisted of wooden blades each 12 feet in length suspended across the full width of the row of peat laid by the spreader. They were so actuated that each knife in turn descended vertically into the cut peat, and was again withdrawn with little motion with regard to the peat other than vertical, thus permitting a clean cut to be made. The knives were so spaced as to make successive cuts at even intervals.

Power to operate the cross-cutting knives was supplied from a sprocket on one of the carrying caterpillars. Longitudinal cutting of the peat was performed by a number of disks so arranged on two parallel shafts that the width of the cut made was 4½ inches. These disks were dragged by a flexible connexion with the spreader.

The bridgework as first tried out was provided also with an adjustable, elevating conveyer at its outside end (Plate XXX), which was arranged to discharge peat carried on the belt after drying, either to small cars on a narrow gauge track placed under its outside end, or to a pile parallel to the working-face, and about 25 feet beyond the end of the bridge. A harvesting device (Plate XXXIII) which it was intended to attach to the bridgework, in a manner similar to the spreader, was constructed and tried out, but for reasons which will be considered later, it was discarded.

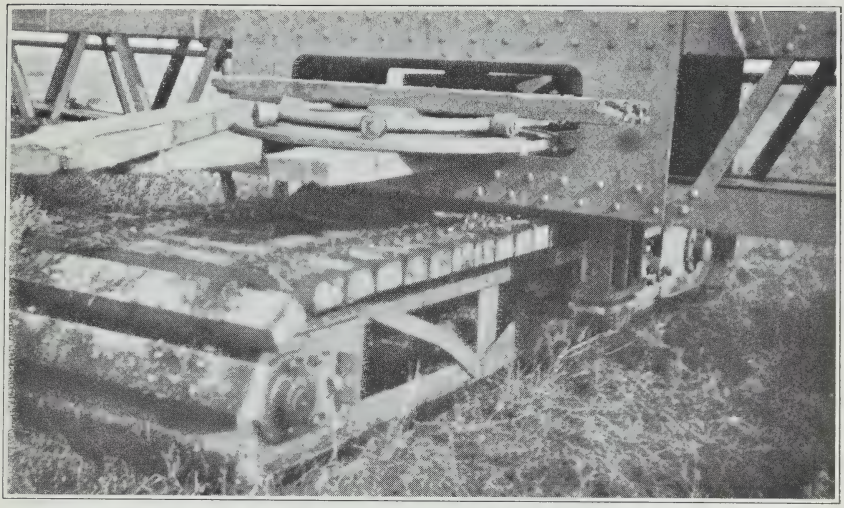
Method of Operation of Plants

Operation of Plant No. 1

The layout of the plant can be best understood by referring to Figure 16 and Plate XXIII.

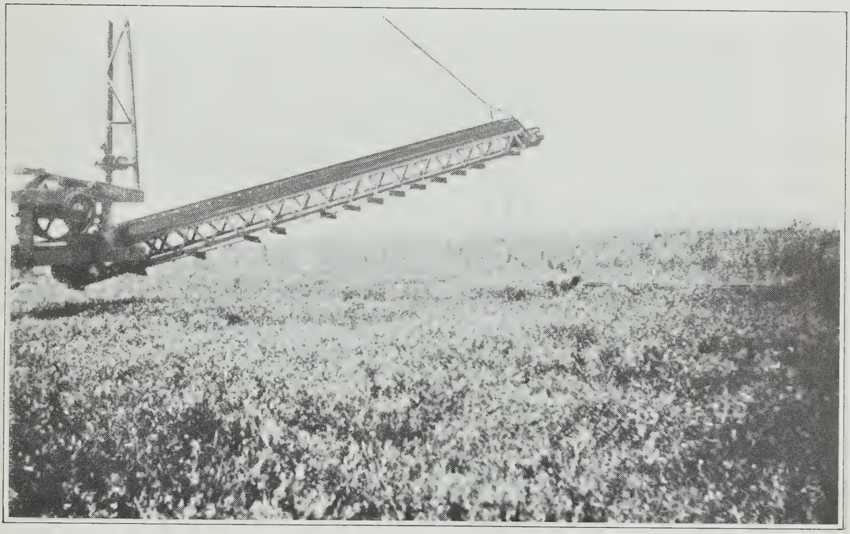
It will be seen that the excavator cuts a prism from the bog about 30 feet wide, and the full depth of the deposit. In operation the excavating element moved back and forth across, and at an angle of 45 degrees with, the line of travel of the machine, cutting a layer of peat which could be adjusted in thickness up to 8 inches from the working-face. The excavating arm was long enough to excavate to a depth of 12 feet, and was adjusted, as required, to dig within 6 inches of the bottom of the bog. When the excavating arm arrived at the end of the working-face, thus reaching the limit of its travel in one direction, the whole machine was moved ahead a distance equal to the thickness of the cut it was desired to make, and the direction of travel of the excavating arm was then reversed and another cut made. The buckets and cutting knives could take care of any roots up to the size of a man's forearm, and when larger roots were encountered, one of the buckets was caught into the root, and, if possible it was pulled out by raising the excavator arm. When this could not be done the excavator arm was simply raised to clear the root, and immediately dropped again, and in the case of large roots, when this had been done two or three times it was possible to either dislodge or chop them off.

Plate XXIX



Plant No. 2—caterpillar supporting outside end of conveyer

Plate XXX

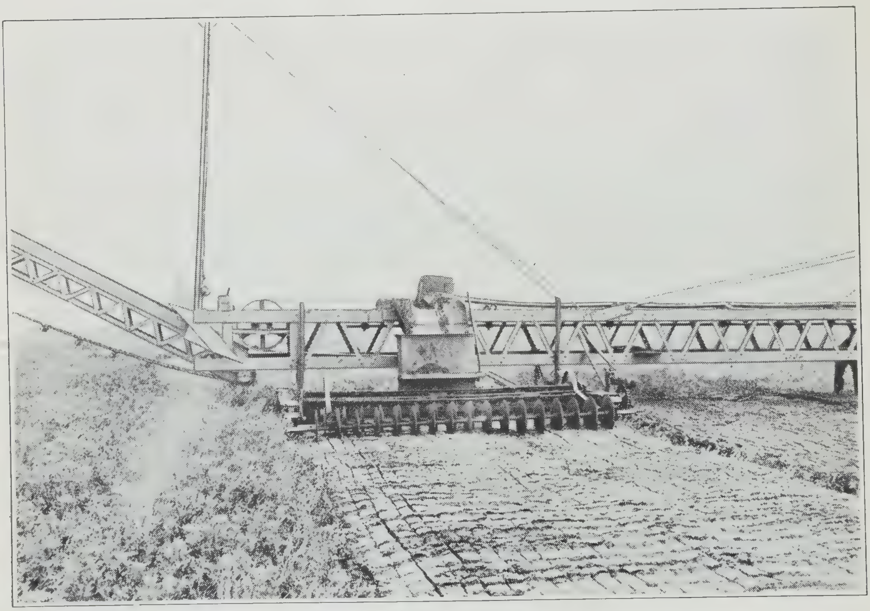


Plant No. 2—stacking and loading elevator on outside end of conveyer

Plate XXXI

Plant No. 2—view from plant looking out on conveyer

Plate XXXII



Plant No. 2—spreader in operation

The water in the excavation was maintained at a depth of about three feet. Although raw peat from the drained portion of the working-face had an average water content of 87½ per cent, it was found that the peat machines operated much more freely and with less power when the peat slop contained about 90 per cent of water. With a proper depth of water in the working-trench the excavator buckets mixed wet peat from below the water-level with drained peat from the upper portion of the working-face in the proportions necessary to produce peat of the desired moisture content. The comparatively high water content of the excavated peat did not materially prolong the drying of the fuel on the field since the excess moisture was free water which rapidly evaporated. It was found also that the employment of peat with this moisture content led to the production of better formed and more durable fuel blocks. The storage of water in the excavation was also of advantage in providing a source of supply of clear water to the boiler.

The excavated peat was carried by conveyer troughs to an enlarged Anrep macerator by which it was macerated and reduced to a homogeneous mass. From the macerator it was delivered by a third conveyer to small steel dump cars which carried it to the drying-ground.

Previous to commencing operations a light steel track in sections of such length as to be easily portable, was laid on the surface of the bog in the form of a rectangle with rounded corners. This rectangle was about 800 by 400 feet, with one of the short sides adjacent to and parallel with the line of excavation, and cars were hauled about it by means of an endless cable to which they were clutched. The loaded cars were hauled along the track from the excavator in the opposite direction to that of the movement of the excavator, around the first corner of the rectangle, and along its sides to the point where the spreader was working. There they were stopped and dumped into the spreader, and were again clutched to the cable and travelled around the other sides of the rectangle back to the excavator to be reloaded.

The spreader moved under its own power, parallel to the track, and at a sufficient distance from it to conveniently receive the slop from the cars. It deposited the peat slop on the surface of the bog in a row seven feet wide by the length of the side of the rectangular track and three to five inches or more in depth depending on the contour of the surface underneath. As the spreader moved ahead this row was cut into strips longitudinally, at the outset of operations, by trailing knives, and later by a number of steel disks spaced about 5 inches apart on a shaft, which were dragged after the machine. This operation continued until a row had been laid the full length of the side of the rectangle.

In the meantime a second line of track was laid a little over 8 feet inside the track from which spreading was being done, and parallel to it. On completion of a row, all cars were run off the working-side of the rectangular track, a short section of track removed at each end, and the corner curves, which were assembled complete on skids to facilitate moving, were placed in their new position, the width of the rectangle being shortened about 8 feet as each row was laid. An arrangement of the cable, automatically adjusted it to these new conditions. During these operations the spreader was turned around, and since it worked equally

well when loaded from either side, the next row was laid in the opposite direction to the one preceding it. Shifting of the working-side of the rectangle was continued as described until the spreading capacity of the rectangle was exhausted owing to its two sides coming together. It was then necessary to stop operations until a new rectangle could be laid out, when work was again continued.

A few days after the peat had been laid out the strips were cut crosswise into blocks. At the outset this work was performed by one man who used an implement composed of three disks conveniently arranged on a long handle. Later in the season the cross-cutting was expedited through the employment of a drum with projecting fins which was rolled over the row by two men.

Labour Requirements for Operations

Fifteen men were required to operate Plant No. 1, viz.: a licensed stationary engineer who looked after all the engines and cable-hauling mechanism, a fireman and assistant who with the help of a spare man supplied the power plant with fuel, an excavator operator and an assistant who stood at the top of the excavation and took care of roots, three men loading cars, a man operating the spreader, a man and assistant stopping and dumping cars of slop, two men moving tracks, a spare man, and a mechanic.

Operating Data Plant No. 1

In 1919, despite the fact that experimental work was conducted and many alterations were made, the following results were obtained:

Month	Hours operated	Rows laid out	Tons
June	74½	32½	357½
July	104	53	583
August	110½	62	687½
September (part)	44	25½	280
	333	173	1,908

Production per hour of actual operation, exclusive of time spent in moving tracks, was in June 4·8 tons, in July 5·6 tons, in August 6·2 tons, and in September 6·4 tons. The time required to lay down a row was: in June an average of 2 hours 17 minutes, in July 1 hour 58 minutes, and in August and September about 1 hour 45 minutes.

The time spent in moving tracks was about 35 per cent of the total time worked, and the total period of actual production of 4 tons per hour; a rate of about 3½ tons per hour for the earlier part and 4½ tons per hour for the last half of the season.

The total length of the working season in 1920, exclusive of Sundays, was 105 days. Causes entirely unconnected with the running of the plant itself prevented operation on 23 days, of which 13 days loss of time was due to delay in delivery and installation of the water-tube boiler. Two days, only, were lost owing to bad weather. This left a possible operating period of 80 days, during which the total time of actual operation for the whole plant including time spent in moving tracks was 52·2 days. One hundred and fourteen hours of the remaining lost time was caused by delays incidental to the operation of the plant, and which might be regarded as normal and to be expected. Loss of an additional 164 hours was due to alterations and experimental work and to delays arising from remediable defects which were largely eliminated in later operation.

The total amount of fuel laid down (day shift only) was 2,500 tons. Average production per hour exclusive of time spent in moving tracks was 6·4 tons; or 4·8 tons per hour of actual operation including the moving of tracks, which took 151 hours, or 28·9 per cent of the actual working time.

On 39·5 working days no peat was laid out and since the average rate of production when working was 4·8 tons per hour, it is reasonable to assume that 1,900 tons more could have been laid out if the plant were working all the time. This would have given a total production of 4,400 tons, which it is estimated could have been increased by at least 25 per cent, by modifying the buckets and cutting knives of the excavator. It is therefore estimated that Plant No. 1 as operated in 1920, but with the known defects eliminated, would have been capable of producing 5,500 tons annually. This is, however, gross production and does not represent the quantity of saleable peat fuel which the machine could have produced.

Operation of Plant No. 2

Instead of cutting a wide prism from the bog as it advanced, Plant No. 2 moved continuously ahead cutting a single layer of peat from the working-face, which was developed parallel with the direction of travel of the machine. (Plate XXVIII.) This necessitated a very long working-face, and a comparatively rapid rate of movement in advance of the whole machine, which was originally geared to travel about 5½ feet per minute, but was later moved at from 8 to 8½ feet per minute.

After the working-face had been developed, a line was carefully laid out at a certain distance from the excavation to guide the operator in steering the machine, since satisfactory operation depended largely on making a uniform cut.

The excavated peat was delivered direct from the buckets of the excavating element into the hopper of the macerator, which in turn discharged it into an equalizing tank. From this it was fed by a screw conveyer through a moulding-spout on the belt (Plate XXXI). An adjustable scraper deflected the peat slop from the belt into the hopper of the spreader.

At the commencement of operation (Figure 18) the spreader was attached to the rear side of the bridgework in such a manner that its inside caterpillar was about 8 feet from the nearest caterpillar of the machine. This clearance was necessary in order to provide a space for moving the machine as new cuts were made. When the machine reached the end of the working-face, thus completing the first cut, the spreader was detached and its hopper removed in order to permit the bridge to pass over it. The direction of travel of the machine was then reversed and the spreader was turned around and attached to the bridge, but on the opposite side and about 12 feet out from the excavator. These operations were continued until the whole drying-area was covered by the laying-out of twelve rows of peat, parallel with the line of travel of the machine, each row being 12

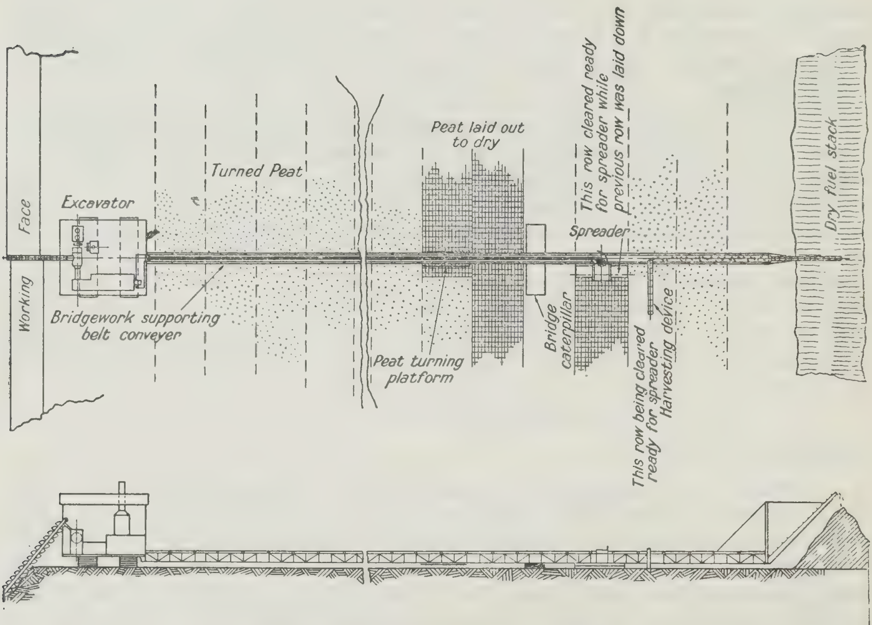


FIGURE 18. Plan of operation of Plant No. 2

feet wide and the full length of the working-face (Plate XXXII). With a working-face of sufficient length to provide the necessary drying-area, the fuel in the first row laid down would be dry when spreading of the twelfth row was completed. The first row provided a convenient supply of fuel for operation of the plant while the drying-field was being spread a second time. After clearing the first row, the spreader was detached from the outer end of the bridgework and placed in position for laying a new first row. It was anticipated that the harvesting of the dry peat and the second spreading of raw peat on the drying-ground would be carried on simultaneously by attaching a mechanical harvesting device to the bridgework just outside the spreader. Under the proposed method of operation

the inner end of the belt would carry raw peat which would be deflected to the spreader, and at the same time the dry peat collected by the harvester would be carried on the balance of the belt and deposited in cars or a storage pile along the edge of the drying-field. For various reasons this did not prove practicable.

Labour Requirements for Operation

Seven men were required to operate Plant No. 2, viz.: a licensed stationary engineer who looked after the engines; a fireman, and an assistant to provide fuel; a man who steered and ran the machine and operated the excavator; and an assistant who stood at the top of the excavation and took care of the roots; and one man on the spreader. Part time of a mechanic was also required for repairs.

Operating Data

Plant No. 2, excepting the spreader was delivered at Alfred in November 1918 and partly assembled. Early in 1919 the assembling of the plant was completed, and a mechanical tryout made. Towards the end of May it was decided to strengthen the driving mechanism of the caterpillars, and it was not until the middle of June that any attempt was made to excavate. On July 7th the spreader was first tried out, and from that date until the end of the season, the time was spent in experimental and development work.

During the season a working-face was developed, without which it was impossible to form any opinion regarding the value of the machine. The excavation necessary to develop this face was made entirely by the machine which was handicapped by the fact that this portion of the bog had never been worked before and was therefore practically undrained. The surface consequently was very uneven, and contained a number of soft spots and holes caused by fire and these occasioned a great deal of difficulty. Operations were also hampered by insufficient water supply, since it was late in the season before the excavation was of sufficient depth to carry the required quantity of water for feeding the boiler.

The spring of 1920 was occupied in completing alterations, which had been left unfinished the previous fall, and the machine, therefore, was not in condition for continuous operation until May 15th. From this time until August 27th it was operated almost continuously under conditions that were as nearly as possible commercial.

Actual working time of the machine was 590 hours during which time 149,250 linear feet of row were laid down, equivalent to a total production of 2,665 tons, based on the assumption that 56 feet of row contains 2,000 pounds of 30 per cent moisture peat fuel.

Average hourly production was therefore 4·5 tons. The length of season, exclusive of Sundays was 105 days. One hundred and eighty-four hours or 17·5 per cent of the possible working period, were lost through delays which might be regarded as normal. Maximum production for one day was 53·6 tons.

Observations Based on Operation of Plants Nos. 1 and 2

Plant No. 1 (Anrep System)

The outstanding weakness of Plant No. 1 was in the spreading system, including the means of transporting the pulped peat from the machine to the drying-ground, and the method of laying it on the drying-surface and forming the peat into blocks.

(1) Cost of labour in spreading was excessive, due to the number of men necessary.

Eight men were required, viz.: 3 men loading cars, 2 men stopping and dumping cars, 1 man operating spreader, and 2 men moving tracks. And in addition to this, a portion of the time of a spare man and a mechanic.

(2) Loss of time in shifting tracks not only seriously lowered productive capacity of the plant, but still further increased the high labour costs due to the number of men required.

On the completion of the spreading of each row of peat on the drying-field, it was necessary to shift the corner curves of the rectangular track to a new position, connect them up, and adjust the cable to the new conditions. This operation occurred at intervals of about one and three-quarter hours. When the combined width of the rows laid out on the field approached 400 feet, it was necessary to stop operation and lay out a new rectangle of track as already described. The delays occasioned by these operations caused a loss of nearly one-third of the total working time. Under the best operating conditions from 25 to 30 per cent of the total working time was required to shift track—during which time the entire plant was idle.

(3) Derailing of cars on the light tracks of the rectangle laid out for transportation of the peat slop to the spreader, contributed largely to delays.

(4) The capacity of the spreading system was limited to the speed with which the car of slop could be stopped, dumped and cleared out of the way of the next car.

It is doubtful if more than 10 tons per hour could be laid out when operating by this method, even supposing everything to be in perfect condition, and this capacity would be cut down to 6 or 7 tons per hour if the time lost in moving tracks were taken into consideration.

(5) In the field-press type of spreader the soft peat mass is dumped directly on the bog and smoothed over by an apron which leaves the surface of the peat level.

This method of spreading has a very serious defect, viz.: that the under surface of the peat spread follows irregularities in the bog surface, with the result that the spread mass varies greatly in depth making the blocks formed very uneven in thickness. This leads to irregular drying, and part of the peat becomes too dry while an equal or greater amount is still too wet to harvest. The result is a very uneven product, unless an effort is made to sort the fuel and harvest it at different times. This, however, is not economic owing to the cost involved.

(6) The spreading system was unsuitable for night operation.

Delays due to derailing of cars and shifting of tracks were seriously increased when operating at night. Owing to the large area over which operations were spread, an expensive lighting system would be required to overcome the added difficulties of operation created by darkness.

In addition to the serious imperfections of the spreading system, Plant No. 1 disclosed in operation a number of defects, due partly to faulty design and partly to unavoidable conditions under which the machine was constructed. The supporting caterpillar elements, which had been specially designed to meet the unusual conditions existing on a peat bog, were found to have serious defects. Steering the machine was also difficult. The Anrep macerator proved unsatisfactory for handling peat containing large quantities of roots. Minor defects in design and construction of the mechanical excavator were also discovered. The heavy weight to be carried owing to placing the excavator, pulper, and power plant on a single platform necessitated unduly heavy construction of the carrying framework, moreover, the assembling of these in a very confined space led to undesirable complexity in mechanical contrivances for handling the material.

Owing to these defects the productive capacity of the machine was much below what had been anticipated, and the labour cost of the manufactured product laid down on the field was correspondingly higher.

Plant No. 2 (Moore System)

The advantages which were claimed for this design at the time it was presented were:—

(1) Lower cost of plant for a given output as compared with the Anrep system.

(2) Reduction in number of men required to operate, namely, seven men compared with fifteen or more for the Anrep system.

(3) Four boys required to perform the operation of cubing, which required not less than twelve workers with the Anrep system.

(4) Number of men required for harvesting reduced by one-half.

(5) Fuel not loaded on railway cars was automatically left in storage piles instead of remaining spread over the drying-field.

(6) No delays incurred in moving tracks or bringing machine back to starting point, which delays are responsible for the loss of 25 to 30 per cent of the total working time, when the Anrep system is employed.

(7) Extremely direct route of the peat from the working-face to the drying-field which it was thought would permit using much less transmission machinery, and would provide more regular feed to the macerator and, therefore, increase its output.

Several of the advantages claimed proved to be illusory, and could not be obtained in actual operation. The extreme length of working-face required for operation was in itself a serious handicap, and would limit the possible sphere of usefulness of the plant as it would only be possible to develop such a working-face on the larger bogs.

From experience at the Alfred bog, it requires about 225 cubic feet of peat slop with 90 per cent moisture content to produce a ton of fuel. When this is spread 12 feet wide and 4 inches thick, which was the section of the row ordinarily laid down by the spreader, 56 linear feet of row must be spread per ton of fuel produced. For a daily production of 60 tons, 3,360 linear feet of row with an average thickness of 4 inches must be laid down; and since a maximum period of about 40 days is required for complete drying, a drying-field has to be provided which will permit the laying down of about 120,000 linear feet. Since the machine provided for 12 rows, the drying-field to meet this requirement would have to be 10,000 feet long in order to ensure the drying of a production of 60 tons per day during a working season of 100 days. A working-face of such length handicaps the starting of operations in the spring. For example, it may be advisable to begin manufacturing operations before the frost is entirely out of the bog. When such is the case the peat made from the first eighteen inches of a working-face 10,000 feet long will be unfit for sale if the frost at time of beginning operations extended to this depth. A working-face frozen to this depth in the late spring is not uncommon.

The extra power required to move a heavy machine on caterpillars over the surface of a bog for long distances would also be a factor militating against the commercial success of such a plant. For an output of 5,000 tons the travel of the machine would be about 280,000 feet.

The proposed plan for the utilization of the machine to harvest the first layer of peat from the drying-area, simultaneously with excavation and spreading of the same area a second time proved impracticable, since an interruption or break anywhere along the line held up the entire excavating and harvesting operations. What was still more serious was the inability to meet the effects of variations in the weather. In case of exceptionally dry weather there was a danger that the peat would become too dry before it was harvested; whereas if the weather were abnormally wet, with poor drying conditions prevailing for any length of time, the operation of the whole plant might be held up waiting for the fuel to dry. When the attempt to harvest by this method was abandoned, the long rows were disadvantageous for the employment of independent harvesting equipment since a cross-section of the drying-area gave fuel in all stages of drying, and convenient blocks of fuel of fairly uniform dryness could not be obtained.

Finally, it was quite evident that Plant No. 2 required more careful operation than Plant No. 1 since the uniformity of the fuel laid down by Plant No. 2 depended very largely on the care taken by the operator, to ensure the supply of a constant quantity of peat to the spreader by the excavator buckets. The principal advantages of Plant No. 2 over Plant No. 1 were the saving of the time consumed in laying tracks under the Anrep system, and reduction in the cost of labour owing to fewer men being required. Without taking into consideration the services of a mechanic required from time to time for repairs on both machines, the Anrep plant (No. 1), had an average hourly production of 4·8 tons with an operating staff of 14 men, and the Moore plant (No. 2) had an average hourly production of 4·5 tons with an operating staff of 7 men.

Conclusions at End of Season of 1920

As a result of the operations carried on with Plants Nos. 1 and 2, in 1919 and 1920, the Peat Committee were able to present certain definite conclusions at the end of the latter season as follows:—

(1) That the Anrep plant as it stands is in no sense commercial.
(2) That the Moore plant under certain conditions might be employed commercially for the manufacture of peat fuel.
(3) That the Anrep excavating element is the superior of the two and the logical one to employ, but
(4) The Moore spreading system is much more efficient, and is the logical spreading system to employ.

The main difficulty with the Anrep machine is the high cost of labour of the spreading system, and the large amount of time lost in changing tracks and in delivering a continuous supply of peat to the field, resulting in reduced capacity. The main difficulty with the Moore system is the excessively long working-face which is required, an inherent difficulty which prevents this type of machine from being employed to advantage on the average bog.

It was, therefore, recommended that a new machine should be built which would combine the Anrep excavating element with the Moore spreading system. The latter, however, required important modifications in the original design before it could be operated in conjunction with the Anrep excavator. Since the rows of peat were to be laid at right angles instead of parallel to the line of excavation, it was necessary to lengthen the belt conveyer from 150 feet to about 850 feet. Moreover, the automatic spreading-device employed in the Moore plant, attached to the bridgework and drawn along as the bridge advanced, had to be replaced by a spreader working independently of the bridgework and carrying its own power equipment.

Designs for the new spreading system had been already thoroughly worked out, and were sufficiently complete to be placed in the shop for fabrication. The construction of a portable belt conveyer, 850 feet in length, to travel on the yielding surface of a bog, and requiring to be frequently moved ahead, presented entirely new problems in the design of machines of this description. In order to reduce the chances of failure to a minimum the Peat Committee, in preparing plans for the new combined machine, secured expert advice and assistance from engineers and companies of wide experience in the design and construction of belt-conveying systems.

It was further pointed out in the interim report of the Committee that:

> It is imperative that the combined plant above mentioned be erected, mechanically tried out, and commercially demonstrated before the Peat Committee can offer a definite opinion regarding the feasibility of manufacturing peat fuel on a commercial scale in Canada; but it must be understood that even though the equipment is placed on the field early next season, it will be absolutely impossible to do more than operate it to determine weaknesses and changes which may have to be made in the design and to give it a thorough mechanical tryout, at the same time of course manufacturing a small quantity of fuel. The commercial demonstration of the combined plant cannot possibly be made until the following season, and its commercial feasibility may not be determined at the end of the same, but the Peat Committee have every reason to believe that the operation of the plant during the season of 1922, will afford sufficient data to enable the Peat Committee to decide definitely whether or not peat fuel can be manufactured on a commercial basis at a profit under conditions existing in Canada at the present time.

Night Operation of Plants

Since the period during which machine-peat can be manufactured during each year is limited to the length of the season during which drying in the open air can be effected, it is desirable that the machines should be run as many hours as possible daily. It was, therefore, an essential part of the investigation of the plants constructed to ascertain their suitability for night operation.

During the season of 1920 artificial lighting systems were installed on Plants Nos. 1 and 2 and both day and night operations were conducted for a short period. It was ascertained that the operation of Plant No. 2 could be carried out as well by artificial light as by day and that the cost of lighting was small. Owing to the automatic operation of the plant, light was required over only a small area, and all that was required could be supplied by comparatively few lights of moderate power located at points where the men operating the machine were stationed. The steering of the machine could readily be accomplished with the aid of a few lights along the line of direction of travel.

This was also the case with regard to operation of Plant No. 1, so far as excavating was concerned. The spreading system employed, however, was found unsuitable for night operation. This, combined with other weaknesses already mentioned, makes the Anrep spreading system unsuitable for operations on a commercial scale under Canadian conditions.

The general result of the experimental work carried on, however, clearly indicated that under proper conditions, and particularly with a suitable spreading system the laying down of peat fuel on the drying-field can proceed at night equally as well as during the hours of daylight.

Operation of Plant No. 2 in 1921

In order to interpret correctly the results of the operation of Plant No. 2 in 1921, it is essential to keep in mind both the objectives sought and the conditions under which its operation was conducted. The primary objective of continuing work with Plant No. 2 was not the production of fuel, but rather to afford opportunity for further investigation in connexion with the various steps in the process of manufacture, and to obtain additional data on which to base estimates of cost of the several operations involved in the complete process from the point of excavation of the raw peat to the delivery of the finished product to the consumer.

So far as was consistent with the attainment of this objective, an endeavour was made to conduct the operations as nearly as possible along such lines as might be expected in a commercial plant with the minimum complement of men, and without the supervision of the engineering staff. Detailed daily records were carefully kept of weather conditions, labour and other costs, delays and their causes, production of fuel, and other matters affecting the efficiency of operation, or which would afford data of value in connexion with the general investigation.

Among the more important experimental work undertaken during the season were various improvements in the spreading and harvesting apparatus, and alterations in and trials of the machine. This experimental work was responsible for a large proportion of the delays in operation. It

must be noted that no attempt was made to put the machine in perfect condition for operation as the expenditures involved by the necessary alterations would have been considerable. Moreover, such alterations were not at all essential for the purposes of the investigation, since the general design of the excavating system had already been unfavourably reported upon. The machine, therefore, operated under a severe handicap throughout the season.

The following table summarizes operating data with regard to Plant No. 2 for 1919, 1920, and 1921:—

TABLE XIII

Operating Data—Plant No. 2, 1919, 1920, and 1921.

—	1919	1920	1921
Total length of working season exclusive of Sundays	....	105 days	107 days
Total days actual operation[1]	....	(a) 41 "	62·3 "
Unavoidable lost time	....	18·4 "	12·4 "
Percentage of season	....	17·5 "	16·6 "
Avoidable lost time	....	45·6 "	32·3 "
Percentage of season lost through delays which might have been eliminated	....	43·4	30·1
Distance travelled, about	45,000 feet	149,250 feet	242,250 feet
Fuel laid down	(b) 500 to 600 tons	(c) 2,665 tons	(d) 3,889·5 tons
Fuel laid down per hour, average	....	3·4 "	5·2 "
Total labour cost to operate plant	$1,023.82	(e) $4,603·33	$3,380.27
Total labour cost for repairs	....	1,138·50	700.77
Labour cost to lay out per ton	....	(f) 1·75	0.869
Cost of cubing per ton	....	(g)	(g) 0.20
Total labour cost ready to harvest	....	....	1.07
Total labour cost if troubles eliminated	....	....	0.807
Maximum day production	....	53·6 tons	70 tons

[1] Average rate of laying down fuel per hour of actual running time of the machine was in 1920, 2665÷(410+180) or 4·5 tons, and in 1921, 3889÷623 or 6·2 tons.

(a) Does not include 180 hours night work which was included to arrive at average production per hour in 1920.

(b) This distance travelled should have produced 800 tons, but no fuel was made during the first three or four cuts when working-face was being opened up.

(c) It is estimated that 2,985 tons of fuel were made by No. 2 in 1920 on a basis of 50 linear feet of row laid out per ton, and harvesting records would seem to confirm this figure, but 1921 records show it requires 56 linear feet of row to produce one ton of 30 per cent moisture fuel, and this figure has been used so as to make a fair comparison with 1921. The apparent greater production in 1920 is accounted for by the fact that part of the fuel harvested was not dried down to 30 per cent moisture content. This was due to the fact that operation was continued late in the season with a view to ascertaining what amount of drying could be effected in the late fall months.

About 200 tons of fuel made by No. 2 in 1920, was used to supply the plant.

About 865 tons of fuel made by No. 2 in 1920 was not dry enough to harvest.

(d) Estimates of fuel made in 1921 on basis of 56 linear feet of movement of spreader check very closely with actual weights.

Total fuel weighed into storage	3,194·5 tons
Total fuel used to supply plant	221·0 "
Total fuel wasted on field in harvesting	116·0 "
Total fuel left on field not dry	358·0 "
	3,889·5 "
Known loss in production through thin spreading, about	450·0 "
Total	4,339·5 "
Theoretical production of 242,250 feet at 56 feet per ton	4,326·0 "

(e) and (f) This figure includes $735.00 cost of night shift, and $700.00 paid to two additional men over regular shifts, who were necessary to look after suction hose through which water was drawn to the boiler. For a fair comparison with 1921 this latter figure should be subtracted from the total, making cost per ton $1.47 instead of $1.75 as shown in table.

(g) Turning and cubing in 1920 for the first part of the season was done by day labour. A great deal of work was done on old frozen peat in an attempt to save it, and the total cost for turning and cubing in 1920 is abnormally high, so that any figure given would be misleading. In the latter part of the season cubing was done by contract for 20 cents per ton.

The improved efficiency of operation of the plant in 1921 over 1920 is clearly shown by the following statement of increases and decreases.

Effective working time was increased by 21·3 days=52%
Linear feet of row laid was increased by 93,000 feet = 62·3%
Average amount of fuel laid down per hour was increased by 1·8 tons = 53%
Maximum production in one day was increased by 16·4 tons = 30%
Unavoidable lost time was decreased by 6 days = 48·4%
Avoidable lost time was decreased by 13·3 days = 41·1%
Total lost time was decreased by 19·3 days = 43·1%.
Total labour cost to operate plant was decreased by $1,223.06 = 26·5%
Total labour cost for repairs was decreased by $437.73 = 38·4%

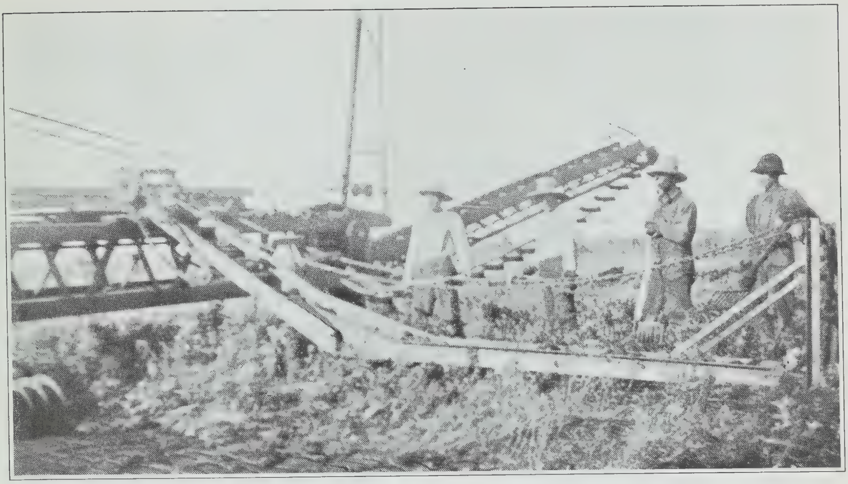
The combined effect of these increases and decreases was reflected in the reduction of the labour cost per ton to lay out the fuel from $1.47 to 0·869, a decrease of 40 per cent.

From the results obtained in operation of Plant No. 2, in 1921, under adverse conditions and with known defects of construction, it would appear that a new plant could be built which would reach the estimated output of 60 tons of fuel per 10-hour day throughout the working season, and that such a plant might be commercially operated under favourable conditions where a 10,000-foot working-face was available. Such conditions would be obtainable, however, on only a few of the larger bogs, and even there in most cases only a single unit could be operated. The defects of the system of excavation as already pointed out, are of such a radical nature that, in all circumstances, the Anrep excavating system would probably prove superior, and the improved results obtained in 1921 in no way invalidate the decision previously arrived at by the Committee.

Plant No. 3

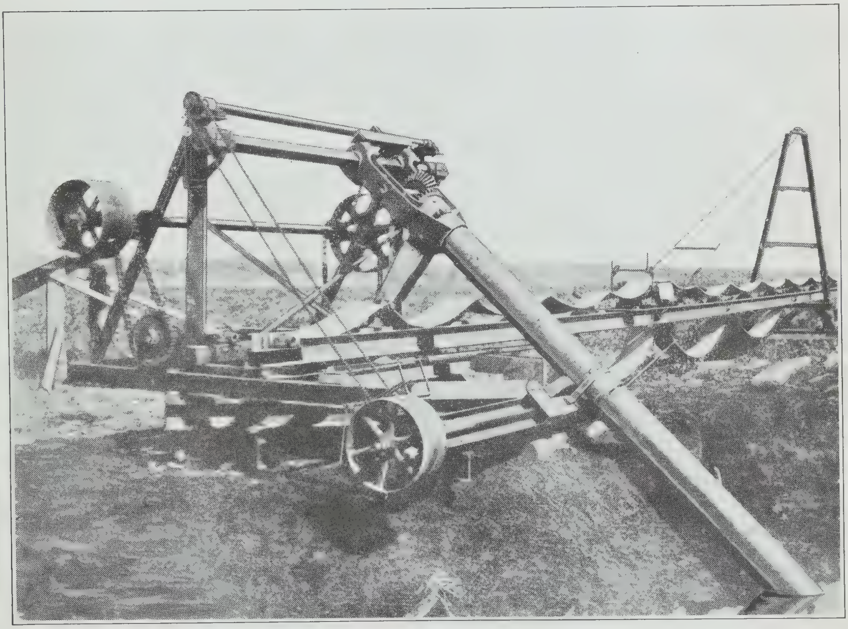
For commercial production of peat on a large scale it is desirable that the machines employed should have the greatest possible capacity consistent with convenience, economy of operation and the construction cost involved. An important field, however, exists for development of peat areas in which such machines cannot be used to advantage. The combination Anrep-Moore plant (No. 4) requires a depth of bog of at least five feet for economical operation. Almost all bogs have considerable areas less than this depth, and many of the smaller ones, containing excellent peat, are not more than five feet deep. For working such areas a smaller machine must be used. Moreover, the capital investment necessary would prevent the employment of large machines on many of the smaller bogs, especially those at a distance from urban centres, but which might be utilized, if they could be worked cheaply, to supply fuel to the surrounding rural communities. To meet such conditions a smaller machine has been developed which is described in this report as Plant No. 3. With a view

PLATE XXXIII



Plant No. 2—mechanical harvesting device

PLATE XXXIV



Peat Committee's Plant No. 3—original design

Plate XXXV

Plant No. 3—excavator, second design

Plate XXXVI

Plant No. 3—spreading system

to obtaining compactness as well as simplicity of design and cheapness of construction an endeavour was made in the first design tried out to combine the operation of an auger excavator with a modified Anrep macerator. These were enclosed in a cylindrical element 12 feet long supported at an angle of 45 degrees with its lower end projecting into the bog. (Plate XXXIV.) The lower 7 feet which was open on one side contained a double-flight, helicoid conveyer which, when pressed against the side of the excavation and moved back and forth along it, operated as an excavator, and elevated the peat to the upper portion of the element in which the pulverizer was situated. The latter was of the Anrep type with fixed and rotating knives, and delivered the pulverized peat on a belt conveyer which carried it to the drying-field. Although numerous experiments were made and various alterations effected in the effort to improve its operation, this combination was not a success. The excavating portion of the mechanism failed to deliver a sufficient amount of raw peat to the macerator, and the latter was easily clogged by roots, and required frequent stoppages for cleaning.

Early in 1922 the machine was rebuilt substituting a small bucket-excavator, similar to the ones used on the larger machines but without the cutting hoops (Plate XXXV) and this proved to be both efficient and satisfactory.

A small experimental macerator somewhat on the principle of the swing hammer pulverizer was built. In this machine the fingers corresponding to the hammers were rigidly attached to the revolving drum while other fingers held in place by springs took the place of the grinding-plate and screen bars. A high degree of maceration was obtained with this machine, but after a thorough tryout of the swing hammer pulverizer, the results obtained with it proved so satisfactory that, in the final design of the No. 3 machine, a small swing hammer pulverizer replaced the experimental one. Transportation of the pulped peat to the spreader was effected by means of a belt conveyer which operated effectively. The peat pulp deflected from the belt by a movable plow, was in the first instance deposited in moulds on the ground. These were bottomless frames 4 feet square divided by partitions in such a manner that when filled with peat and lifted from the ground the blocks would be left on the surface. This required the services of two workmen, one on either side of the belt. When a frame on one side was filled, the flow of peat pulp was deflected to the other side, while the operator levelled the surface of his moulds, lifted the frame and moved it to the new position. These alternating operations continued until the end of the belt was reached. The conveyer was then moved ahead and a new row laid down in the same manner.

This method of spreading was found to be quite practicable, but entailed a considerable loss of time and a maximum amount of labour. A mechanical spreading-device was therefore designed to be driven from the machine. A frame (Plate XXXVI) which projected to the far side of the belt, was fastened to the deflector on the belt conveyer, and in this was swung a tapered box extending from a little below the level of the belt down to the surface of the bog on which it rested. A moulding-spout was provided at the lower end of this box which could be turned to deliver the peat in either direction, and an endless cable was installed along the belt conveyer, parallel to the belt and driven by a reversible drum on the inside end of

the conveyer. A clutch on the unloading carriage engaged this cable and permitted the operator to control the movements of the spreader in either direction. This device was completed too late in the season to enable the machine to be operated under commercial conditions; but from the short trial which was made, the device appeared to work very successfully. Peat laid down by this spreader was cross-cut by hand, which in a small plant of this kind is quite practicable, without necessitating an extra workman.

Plant No. 4. Anrep-Moore System

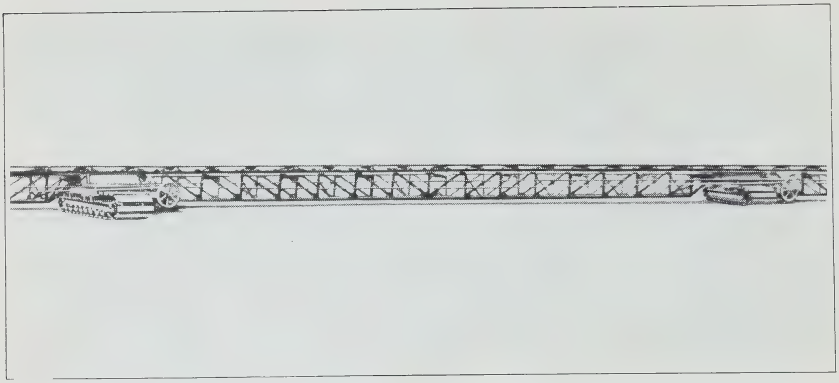
When it had been ascertained from the actual operation of Plants No. 1 and No. 2 that the Anrep spreading system had serious drawbacks, and that the Moore excavating system was impracticable, the Committee recommended that the best features of the two plants be combined. The Anrep excavator was demonstrated to be efficient in operation, and it was evident that excavation of the raw peat could be satisfactorily and economically accomplished by a machine of this type. On the other hand, the Moore spreading devices being self-contained and automatic in action, not only permitted a great saving to be made in labour costs, but it was clearly shown that by their use costly delays could be avoided.

When authority to install and try out a combined plant employing the Anrep excavator and the Moore spreading system was obtained, the Committee began the design and construction of the new plant. Owing to limited funds it was decided to utilize the excavator already built, and to operate the new plant by means of combining the steam-power installations of Plants No. 1 and No. 2. It was necessary, however, to design and construct a portable belt conveyer to operate in conjunction with the Anrep excavator, and a new spreader. Parts of the latter were fabricated in outside factories, but the machine was completed and assembled at the small machine shop on the bog. The belt conveyer was built from the general design and plans prepared by the engineer for the Committee, but the working drawings, details and construction were executed by the Malcolmson Engineering Corporation of Chicago, and the Canadian Link-Belt Company of Toronto.

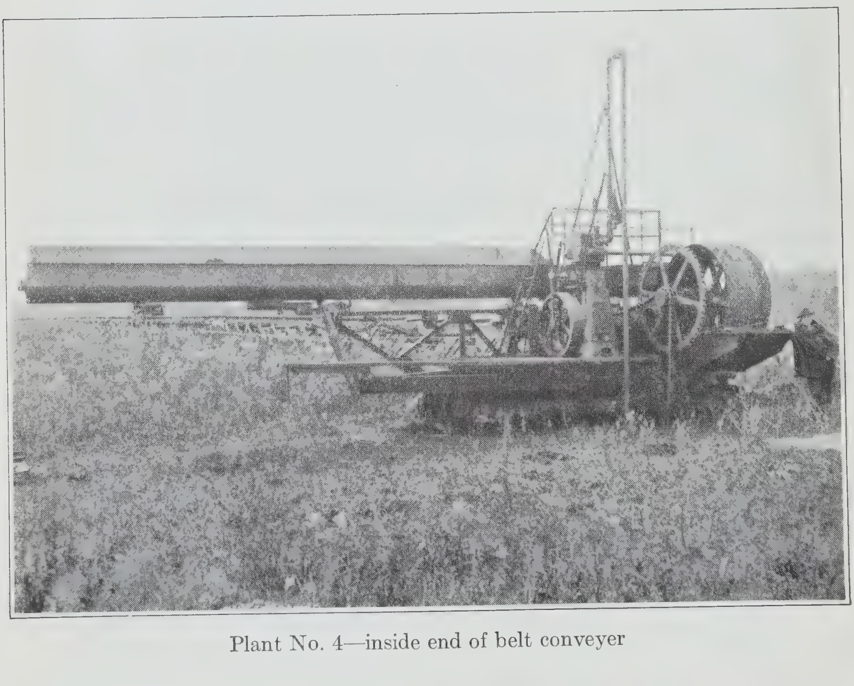
During the early part of the summer of 1921 a number of alterations were made to the Anrep excavator to prepare it for use with the combined plant. The first carload of the new conveyer parts arrived at Alfred on June 1st and during the month the remainder of the conveyer parts arrived at the bog. The assembling of the conveyer was immediately begun and on August 5th its installation was sufficiently complete to permit it to operate under its own power. Excavated peat was delivered to the belt of the conveyer on August 20th. A demonstration of the operation of the entire plant was made on August 26th in the presence of members of the Peat Committee and others.

The new combination plant as originally installed (Plate XXXVII), consisted of the modified Anrep excavator and macerator, the new belt conveyer, and a new spreader. Later on in the season, the Anrep macerator was replaced by a swing hammer mill. Previous to assembling the combination plant the third caterpillar element of the No. 1 excavator was enlarged to correspond with the others, which were fifty per cent larger

General view of Peat Committee's combined Anrep-Moore plant, Plant No. 4



Plant No. 4—section of spreading-conveyer



Plant No. 4—inside end of belt conveyer

than when first installed. The 4 by 5-inch twin engine and the Dake engine used on Plant No. 1 were replaced by a 7 by 8-inch engine. This permitted the excavating element to be driven by a single engine. To enable this change to be made, alterations were made in the transmission machinery and the controlling mechanism was arranged more conveniently and made automatic.

One of the principal difficulties encountered in operating the No. 1 excavator was that of moving it ahead an equal distance for each cut, as this depended entirely on the care exercised by the operators. A new automatic method of control was, therefore, designed which accurately adjusted the distance moved ahead, thus permitting uniform and continuous operation of the machine. This resulted in a marked reduction in the time lost by the operator in moving the machine ahead, and also increased the capacity of the excavator.

Portable Belt Conveyer

The portable belt conveyer was 850 feet long and consisted of a rubber belt carried on a light steel girder composed of ten sections each 85 feet long, rigidly connected together. (Plate XXXVIII.) The girder was supported on eleven caterpillar elements. Ten of these were of the same design and dimensions, while the eleventh, supporting the inside end was of similar design but larger to enable it to carry the engine driving the mechanism of the belt and the loading hopper. (Plate XXXIX.) For carrying the belt the girder was provided with rollers 30 by $4\frac{1}{2}$-inches, which were spaced on 5-foot centres on the top side and 10-foot centres underneath. Hyatt roller bearings were built into the rollers in order to reduce the friction loss to a minimum. These rollers supported a 24-inch, five-ply canvas conveying belt, 1,700 feet in length with one-sixteenth of an inch rubber covering on the carrying side. The belt and carrying caterpillars were driven from an engine on the inside caterpillar element. The belt moved at the rate of about 320 feet per minute.

The unique feature of the conveyer was the method employed to move it. In order to lay on the field 10 tons of standard saleable peat fuel per hour, it was necessary to move the belt conveyer every $1\frac{1}{4}$ hours a distance of $13\frac{1}{2}$ feet in a direction parallel to the line of travel of the excavator, and this necessitated a lateral movement of 108 feet during a working day of 10 hours. To accomplish this movement a corresponding axle of each caterpillar was provided with a sprocket wheel connected up through worm gearing to a 30-inch cable sheave which was located clear of the caterpillar so that all the sheaves were in line. (Plate XL.) An endless $\frac{7}{16}$-inch cable, wound once around each sheave, was led to an operating drum located on the inside caterpillar, which gave it motion. The slack was led out to an anchor sheave on the outside caterpillar, and thence to the outside operating sheave on it. (Plate XLI.) When the drum was operated all the sheaves were therefore given similar motion provided there was no slip. This, however, could hardly be expected, and the sheaves were, therefore, connected to their shafts by clutches. This arrangement permitted any one of them to be disengaged, and to be brought into line by means of a hand crank. This precaution was found to be scarcely necessary, since no deflection from the line was visible to the eye after 40 to 50 moves.

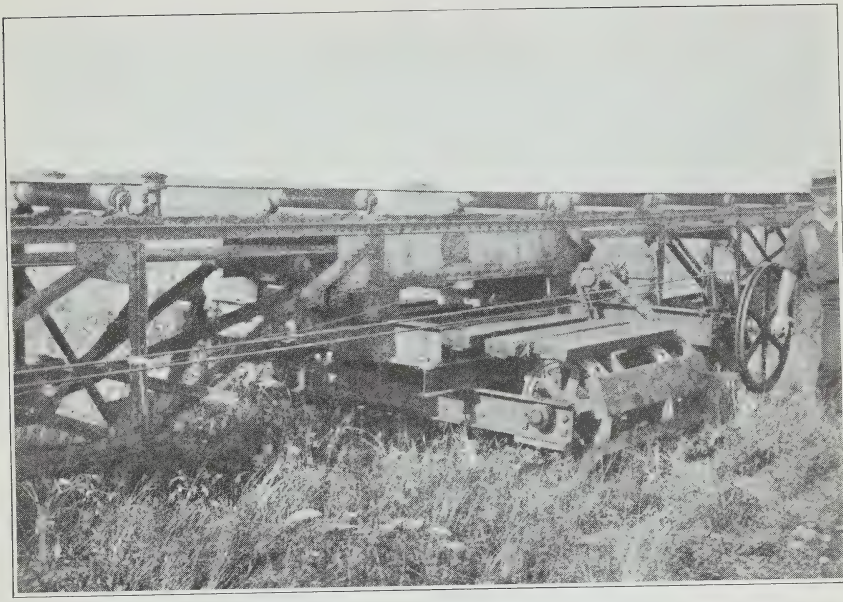
An unloading carriage was provided to run under the belt and on top of the box girder, the outside top angles of the girder serving as rails. This carriage was free to run the entire length of the belt, and provided a flat table over which the belt passed to permit a plough to deflect the peat pulp off the belt. In passing over the unloading carriage the belt was sufficiently elevated to permit the receiving hopper of the spreader to project underneath it. This permitted the peat mass to be continuously unloaded into the spreader. (Plate XLII.) The unloading carriage was attached to and moved in either direction by the spreader.

On the inside end of the belt conveyer, a hopper 18 feet long, provided with a 16-inch spiral conveyer, was installed at right angles to the belt and parallel to the direction of movement of the excavator. This permitted the delivery spout from the macerator to discharge into it while the excavator moved ahead 13 to 18 feet, as might be required, to provide peat for a row laid down by the spreader. (Plate XXXIX.) A suitable spout in the hopper delivered the peat in a stream on the belt at about the same speed as it was moving, namely, 320 feet per minute.

Spreader

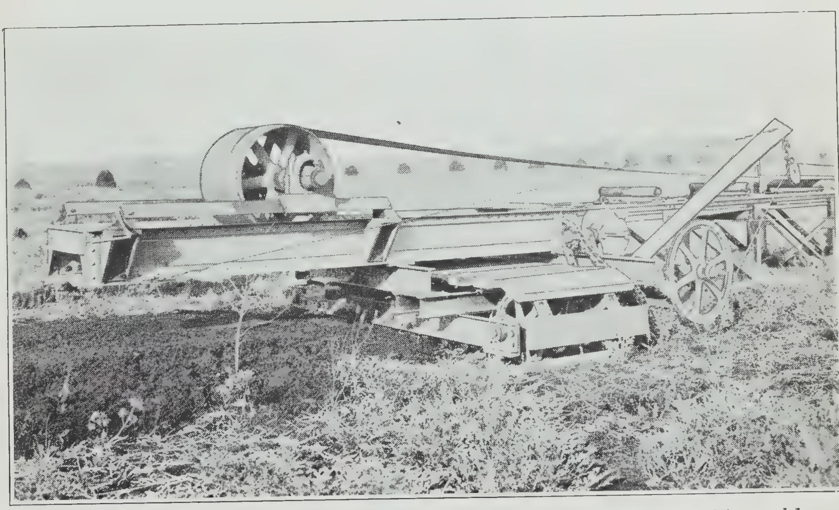
In the Moore system the spreading-element was attached to the bridgework carrying the belt conveyer, and was dragged along by it, thus laying rows at right angles to the conveyer and parallel to the line of excavation. The operation of the new, combined plant required that the rows should be laid at right angles to the line of excavation and parallel to the belt conveyer. The general principles of the No. 2 spreader were retained; the only modifications being those necessary in the structure and in the method of operating. The spreader consisted of a sheet-steel box 12 feet long, of sufficient dimensions to contain a 14-inch spiral conveyer. This box was pivoted at its ends between two caterpillar carrying-elements which permitted it to be tipped in either direction. A moulding-spout, designed for adjusting the depth of the peat laid on the field, was extended along each side of the bottom of the box. The width of this spout was equal to the length of the box. When the box was tipped in one direction, the spout on that side came into contact with the bog surface and bore heavily enough on it to smooth down small roots or twigs and knolls of moss. When this was done the spout on the opposite side was sufficiently elevated to prevent the peat mass from flowing out through it. When the box was tipped in the opposite direction this operation was reversed. This arrangement permitted the spreader to be reversed so as to spread in the opposite direction, by simply operating a lever. The peat slop was conveyed from the unloading carriage on the bridgework by another spiral conveyer, installed in a suitable trough, the discharge end of which was fixed over the inside end of the spreader box. A small hand-hoist convenient to the operator was employed to raise and lower the discharge end of this trough, in order to adjust it in case the spreader tipped one way or the other through unevenness of the ground. The peat slop was uniformly distributed in the spreader box by the spiral conveyer and forced from the moulding-spout in a ribbon of even thickness. To accomplish this the spiral conveyer was tapered from full size at the inside end to almost nothing at the outside end.

PLATE XL

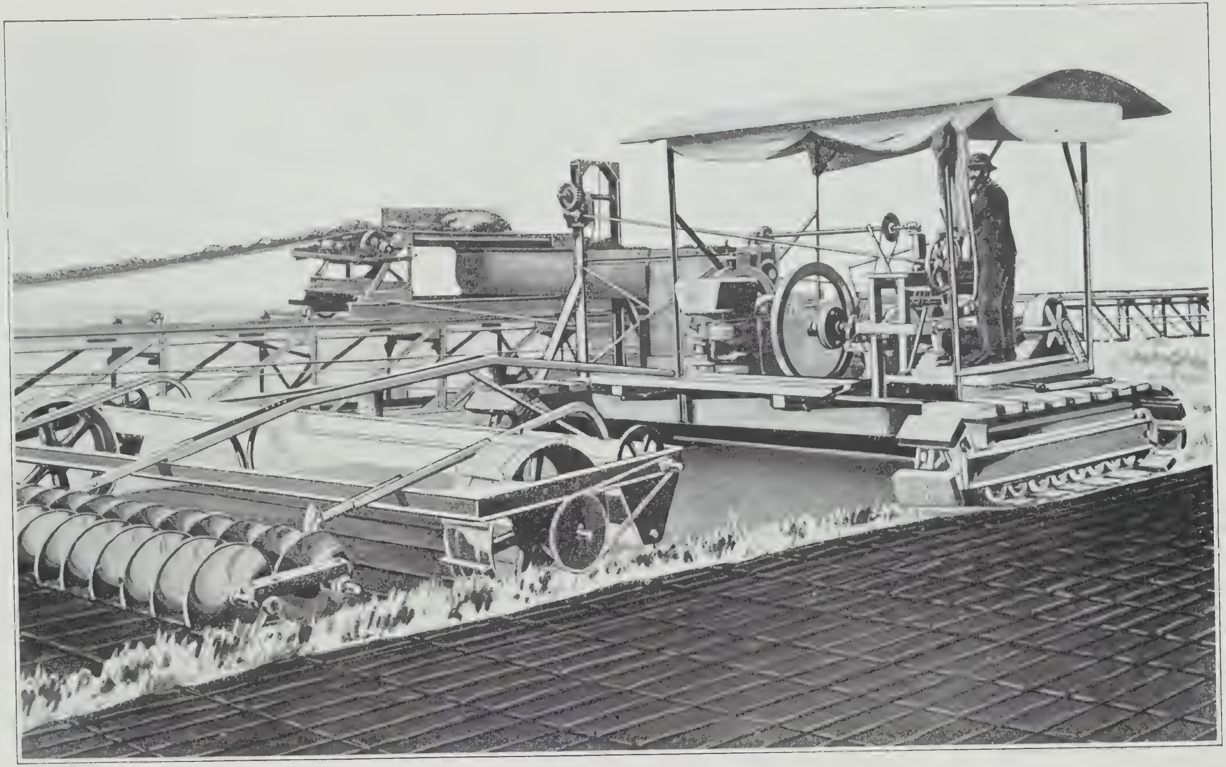


Plant No. 4—belt-conveyer caterpillar showing driving mechanism

PLATE XLI



Outside end of spreading-conveyer showing anchoring sheave of propelling cable



Plant No. 4—spreader in operation; also shows cutting-device

The spreader was operated by a 10 h.p. gasoline engine which drove the caterpillars by means of two Reeves variable-speed shafts, one of which was used to regulate the speed of travel of the spreader and the other to steer it. The speed of the spiral feeding the spreader was constant, but the speed of the one in the spreader box varied as the speed of travel. The speed of the spreader could be varied from 6 up to 18 feet per minute, and could thus be regulated to take care of the exact amount of peat slop being delivered by the belt at any time, and thus a uniform layer of peat was laid on the drying-field.

The spreader was also provided with a cutting-device which was trailed behind it (Plate XLIII). This consisted of a rectangular steel frame carried on two wide wheels equipped with cleats. To the rear of this frame were fastened two parallel steel shafts, on each of which tapered disks, 16 inches in diameter, were spaced about 10 inches apart. The disks were staggered, so that, when drawn along through the peat, the row was divided into strips about 5 inches wide. In the fore part of the framework three knives, 12 feet long and 6 inches deep, were operated by a mechanism, driven from the carrying-wheels, which forced them into the peat at right angles to the direction of travel of the spreader, cutting it crosswise about every 10 inches. The operating mechanism was geared so that these knives cut vertically into the peat and were pulled out again vertically without disturbing the surface of the peat.

Operation

The method of operating the Anrep excavator has already been described under Plant No. 1. The conveyer framework remained stationary, while the spreader laid down a row about 775 feet in length and 12 feet wide alongside. During this time the excavator moved forward a distance of 12 to 14 feet or more as might be required to provide peat slop to fill the row, discharging the excavated and pulped material into the long trough on the inside end of the conveyer. When a row was completed the excavator was stopped and the conveyer was moved ahead for another row. At the outset the spreader moved into its new position alongside the conveyer under its own power. As a considerable loss of time was caused by this operation a simpler method of moving the spreader was devised. Two low, transfer trucks were fastened to the rear side of the conveyer, one at each end, in such position that the spreader by running straight ahead after a row was finished arrived on the transfer truck (Plate XLIV) and as the conveyer moved ahead the spreader was pulled straight sideways the desired distance. Meanwhile the cutting-device was detached and moved to the opposite side of the spreader and its direction of travel simply reversed. In this way the delay of moving was reduced to less than 10 minutes, and by further slight modifications of the spreader the time can be reduced to 5 minutes.

The working-trench developed by the excavator divided the drying-field into two equal and similar rectangular areas lying on either side of it. (Figure 19.) This arrangement, it was found, is preferable to excavating along one side of the drying-field, which would necessitate bringing the plant back to its starting point every time the field is covered. At each end of the field and at a convenient distance beyond the end of the

excavation, a track was laid at right angles to the excavation and extending the full width of the drying-area on both sides of the trench. When the plant reached the end of the excavation it was run ahead until the conveyer rested over this track. The excavator was then turned around the end under its own power and run into position on the other side of the trench. Meanwhile the end caterpillars of the conveyer were detached, the conveyer jacked up and harvester car trucks run underneath. The conveyer was then moved endways along the track on the car trucks to its new position. The end caterpillars, being interchangeable, were reversed. The only other change necessary was that of turning the unloading carriage around on its track. When these changes had been effected the plant was in position for operation on the other side of the trench. The entire operation of turning the plant required about 24 hours.

Labour Requirements for Operation

The following statement shows the number of workmen employed to operate Plant No. 4 in 1922, with rates of wages paid per 10-hour day:—

Engineer and foreman	$ 7 00
Excavator runner	4 00
Man at cutting-face	4 00
Fireman No. 1 boiler	3 50
Fireman No. 2 boiler	3 50
Man putting fuel on boiler platforms	3 00
Man trimming working-face	3 00
Man attending belt conveyer	3 00
Spreader operator	4 00
Spare handy man	5 00
Total	$ 40 00

To supply the boilers with peat fuel required labour equivalent to that of two men. If such a plant were operated continuously, the inside end of each row could be left on the field, when harvesting, and then gathered into piles convenient to the line of travel of the excavator. This would cut the labour in half, and save the laying of tracks to bring the fuel to the plant.

When working under commercial conditions the man trimming the working-face would be dispensed with. During experimental work with Plant No. 1 in previous years the working-face had become irregular. The straightening of the line left portions of the area to be excavated slightly broader than the width of the cut made by the machine and this extra width had to be trimmed off by hand. This condition was entirely due to defective operation during experimental work with Plant No. 1, and would not occur in regular operation.

For a properly-installed plant operated by steam power the labour requirements would be:—

Engineer and foreman.
Excavator runner.
Man at cutting-face.
Fireman.
Man bringing fuel to platform.
Man attending belt conveyer.
Spreader operator.
Spare handy man.

The services of a mechanic would also be required from time to time to make any necessary repairs.

If operated by electrical energy either purchased or generated by a Diesel engine, the services of the fireman and man bringing fuel would be dispensed with.

Operating Data

Repeated tests show that a cubic foot of raw material in the Alfred bog weighs 62·5 pounds and the average water content is in the vicinity of 88 per cent, so that $\frac{12}{100}$ of 62·5 or 7·5 pounds of absolutely dry material is available from every cubic foot excavated. This will produce $7 \cdot 5 \times \frac{10}{7} =$ 10·7 pounds of peat fuel with 30 per cent moisture content. It is, therefore, necessary to excavate 187 cubic feet of raw peat in order to lay down the equivalent of a ton of 30 per cent moisture peat, which is hereinafter termed standard peat fuel.

From a number of observations made at various times throughout the season and on different parts of the field, it was determined that on the average a ton of fuel should be harvested for each 50 linear feet of travel of the spreader. The method of observation employed was as follows:—Four rows were harvested simultaneously by the harvester. The length of each of these rows was carefully measured, and the peat taken from them was weighed. On the basis of the above computation, since the rows were 12 feet wide, the theoretical depth of spreading to produce this amount of fuel would be 4½ inches. From numerous observations and actual measurements made, the average depth of spreading was found to be somewhat more than this.

During the season of 1922 the total travel of the spreader was 237,295 feet, which at 50 linear feet to the ton should have produced 4,746 tons of fuel. Actually 3,448 tons were harvested and weighed over the scales, 565 tons were used under the boilers, and 255 tons were sold to local customers who harvested and drew the fuel from the field in their own wagons.

Owing to unavoidable delay in the installation of new loading and storage equipment which had been rendered necessary by the destruction of the storage trestle and loading platform by fire in November of the previous year, the peat spread on field No. 1 in the earlier part of the season remained on the drying-field until its moisture content had been reduced considerably below 25 per cent. This led to loss not only through excessive drying but from disintegration and crumbling of the blocks as a result of which a large amount of fines was produced, and there was an abnormal loss of fuel in harvesting. The known loss of production due to excessive evaporation of moisture is estimated to have been 130 tons. The loss in harvesting was therefore about 348 tons, or approximately 7 per cent of the theoretical production. The greater part of this loss occurred on field No. 1.

On the drying-areas spread during the later part of the season the loss in harvesting was estimated to be about 5 per cent. On a large portion of these drying-areas peat was spread for the first time, and since better results in harvesting can be obtained as the surface of the drying-ground becomes levelled by continuous use, it was considered that this could be safely taken as an average figure to represent normal losses in harvesting operation.

For the purposes of recording operating data the period from June 2nd to August 23rd inclusive was chosen as the best to represent commercial operation. Until June 2nd, work was irregular, due to lack of fuel and experimentation with the new macerator, and after August 23rd the condition of the field and the extreme difficulty in moving around the north end of the working-trench for the first time, produced an abnormal situation. During the period under consideration a move was made around the south end of the excavation and 192,670 linear feet of row laid out. This corresponds to a total quantity laid down of 3,853 tons of which 95 per cent or 3,660 tons, were saleable, and this is equivalent to:—

84·0 tons saleable fuel per 10 hours machine-running
74·7 " " " " 10 " including moves
66·1 " " " " 10 " " normal delays.

The following table shows the distribution of time during the period mentioned above:—

TABLE XIV

Operating Data of Plant No. 4

Total days elapsed			83·0
Less Sundays			12·0
Total working days			71·0
Add overtime during this period			2·5
Total working days possible (10 hrs. each)			73·5
Subtract delays as follows:—			
Normal—Moving	5·41		
Weather	2·57		
Plant troubles	6·35		
		14·33	
Need not occur again:			
Turning	0·76		
Alterations	3·83		
Tests	0·91		
Bridge on ground	0·71		
		6·21	
Can be eliminated:			
Power troubles	3·42		
Caterpillar troubles	2·80		
Moving around end	2·42		
Spiral drive	0·75		
		9·39	
			29·93
Total time of actual excavating			43·57
Add normal time moving conveyer 265 moves at 10 min. each			4· 4
Normal time moving around end			1· 0
Normal time plant troubles			6·35
Total time in normal operation			55·32 days
During the period under consideration the spreader laid 192,670 linear feet of row equal to			3,853 tons
Wastage in harvesting 5 per cent			193
Net amount of saleable fuel			*3,660 "
Or, per day of 10 hours for 55·32 days			66·1 "

Best days operation June 27th when 84·1 tons were laid down in 7¼ hours, or, at the rate of 11½ tons per hour gross, equivalent to 10·8 tons saleable fuel per hour.

*If hydro-electric power were used this would represent the net production of saleable fuel, but in the case of a steam-power installation the amount of fuel required to generate power must be deducted in order to arrive at the amount actually available for sale.

Observations based on the Operation of Plant No. 4

In order to keep within the limits of time and money fixed by the Government, the Peat Committee had to undertake the demonstration of the combination plant in 1922 in the face of the following handicaps:—

1. More than one-half the drying-field which had to be used was virgin bog on which no improvements could be made other than clearing off the standing trees and shrubs.

2. The excavator had to be operated along a working-face which was so irregular as to occasion serious loss of capacity from time to time.

3. A number of ditches dug in the No. 1 drying-field during the previous undertakings on the Alfred bog, and which run at an angle to the belt conveyer, had to be crossed thereby causing delay in the operation of the plant.

4. The space available at either end of the excavation was not suitable for moving the plant around the end, when changing from one field to another.

5. The framework of the Anrep excavator was not designed to carry the more powerful equipment necessary to increase the capacity of the plant from 6 tons per hour to over double that amount.

6. The supporting caterpillars of the excavator were defective in design.

7. In order to increase the macerating capacity the desired amount a new machine had to be installed and adjusted, or the two macerators from Plants Nos. 1 and 2 connected up in parallel. As the Anrep macerators had already given so much trouble, they would have had to have been redesigned to be of commercial value, and as it was known that the other type of macerator would give a better grade of maceration and was free from the defects of the Anrep, the first mentioned alternative was adopted by the Committee.

8. Without an entirely new installation there was not enough power available to enable the various elements of the plant to operate to their capacity.

9. Owing to the dry peat at Alfred having been consumed by the fire in the fall of 1921 there was very little suitable fuel available to start up the plant and this condition continued until about the end of June when the new fuel became available for use. It was expected that the fuel left on the ground not dry enough to be harvested in the fall of 1921 could be used, and this would have been possible in June had it not been for the abnormally wet weather.

Items 1, 2, and 3 were largely eliminated during the season. Items 5, 6, and 7 could have been completely avoided without further experiment had there been time and money available. The new installation necessary would, however, have taken up most of the season and could, therefore, have been used for only a short time. As the Committee did not own the Alfred property, and no plans had been made for the future of the plant, it was not considered advisable to rebuild the plant.

The new macerator mentioned in item 7 proved to be very efficient. In view of the results obtained from operation of the swing hammer mill installed for experimentation, it is believed that the substitution of pulpers of this type for the ordinary macerators with rotating and fixed knives will be a decided improvement in the process of manufacturing air-dried machine-peat fuel. The small size of the machine and lack of power prevented actual demonstration of the capacity aimed at by the Committee, but enough data were obtained to leave no doubt as to the results which would be possible with a larger size machine and with more power.

Item 9 was a local condition which would not exist again if the Committee's recommendations for power were adopted.

Taking into account all the conditions under which Plant No. 4 was operated, the opinion is expressed that very excellent results were obtained in the 1922 demonstration, and with a re-designed machine and the handicaps removed it is more than probable that even better results will be obtained, than are shown in the estimates of cost of operation appearing laters in this report.

Special Problems Dealt With

During the course of the investigation several specific problems in design were encountered, all forming part of the general development of plants manufacturing machine-peat fuel, and as the discussion of these problems is more or less common to all the machines, they are taken up under separate headings as follows: caterpillars, excavators, macerators, spreaders, and power.

Caterpillars

The transportation of heavy working machines over a bog presents serious difficulties. These are due to the yielding surface, and to soft spots and depressions in the bog resulting from the destruction of the surface mat of vegetation and fibrous material by fire or other causes. The method heretofore employed has been to carry the machines on tracks supported on timbers laid on the surface of the bog. Such a method involved constant laying of new tracks in advance of a machine and removal of those passed over which caused loss of time and added to labour costs.

It was considered that the use of caterpillar elements to support and carry the entire working plant over the bog surface if practicable and economical, would provide a satisfactory means of avoiding the losses of time and added labour cost incidental to the moving of tracks. Moreover, it would make it possible to operate the plant continuously, thereby increasing its production.

Caterpillar traction had been successfully adapted in the construction of ditching-machines and tractors for various purposes. The employment of such machines, however, had been almost entirely under conditions where a comparatively firm surface was available to carry them. The use of caterpillars to move large and heavy machines on such a yielding surface as that of a peat bog presented special problems.

A small peat plant carried on caterpillars had been built and operated at Farnham, Que., several years before, and small caterpillar tractor elements had also been used to move the spreader of the plant built at Alfred in 1912-13. Although both these installations were on a small scale, the experience thus gained, afforded some indication of the bearing-surfaces required and other data of some practical value.

There are two ways in which the weight of a machine can be transmitted to the ties of caterpillar aprons. In one case small rollers are built into the joints of the chain forming the apron, and the weight is then transferred to the ties through runners which slide over the rollers. In the other, a number of wheels are provided fixed rigidly to the frame of the machine, and these wheels run either on the apron chain as a track, or on some other fixture fastened to the ties which may serve the same purpose.

It was thought that the first of these methods of construction would be better adapted to the special conditions due to operating on the bog surface, and the caterpillars built for both Plants Nos. 1 and 2 were specially designed in accordance therewith. In operation these caterpillars were found to have several serious disadvantages, which caused numerous breakages and delays. Still, as the work being carried on was only of a temporary character and solely for purposes of investigation, it was considered advisable to continue the use of the caterpillars with their known defects for the period of the experimental work.

Towards the conclusion of the investigation it was ascertained that caterpillars superior in design to those built by the Committee had been developed by a firm in the United States and were being successfully employed on surfaces similar to those which would be met with in working Canadian bogs. Several defective features of design in the caterpillars used by the Committee, which led to frequent breakages and loss of time, and necessitated costly repairs, were entirely eliminated in these machines. Moreover, the working parts were more readily accessible, and any necessary repairs could be easily and rapidly effected.

The employment of caterpillar elements to carry large peat machines on the bog may, therefore, be regarded as no longer presenting any serious problem since equipment specially adapted to the purpose can now be purchased in the open market. The conclusion was reached, as a result of the investigations, that there can be no doubt as to the desirability of using caterpillars for transportation of heavy machines over peat bogs.

Excavators

The difficulty in excavating peat mechanically is due to two causes: roots embedded in the peat mass, and the difficulty of supporting a heavy machine on the soft surface of the bog or on the underlying strata. So far as strength and capacity are concerned many standard shovel or bucket excavators could be used but the standard machines are too heavy to be conveniently supported on the top of the bog, and even were this possible, excavating peat by any method which does not give a complete and uniform mixture of the different layers of the bog would not be satisfactory. Besides, with any shovel or bucket excavator, great care would have to be taken not to dig too deep, and the churning of the shovel would so mix the peat with the water that a large part of it would be wasted.

So far as is known no shovel or bucket type of excavator has been used commercially to excavate peat, although excavators of this kind would be quite strong enough to take care of any roots, no matter how large.

A number of excavators of the endless chain and bucket type have been built, of which the Peat Committee machines are examples. Ekelund, in Sweden, seems to have built a practical machine which he was able to operate on the bottom of his bog, due to its unusually hard nature, but this machine could not be used on the majority of the known bogs in Canada. Wielandt, Strenge, Dolberg, Schlickeysen, and other German designers have also built machines which are more or less practical, and all of them are supported from a structure on the top of the bog. Prof. Pierce F. Purcell reports, however, that all their machines have more or less trouble in taking care of any but very small roots. Other investigators have suggested and some have built various types of floating excavators but although there is no doubt that a dredge could be built to excavate peat, on account of its unstability it would be open to difficulties in getting the excavated material to the drying-field, and, due to the amount of water in the excavation, and the churning up of this water, a considerable amount of the raw peat would be lost. Moreover, it is hard to imagine how a uniform mixture of the different layers from top to bottom could be obtained by this method.

The unique design of the excavating element of the Peat Committee's excavator, and the Anrep principle of supporting and operating it are largely responsible for its success. In the original Anrep excavator large and heavy buckets were simply hung between chains which were not supported between the head and tail chain-wheels. The result was that when an obstacle was encountered the buckets dug in deep and stopped, and the regularity of the face was spoiled. The first improvement was fixing the bucket chains in guides so that they must develop a smooth regular face, but the large buckets still brought up roots entirely too large to be taken care of by the conveying machinery and the macerator. During the work at Alfred in 1913-14 a picking-table was at first installed to take care of the smaller roots and later a shredding device was built into the macerator to grind them up. This machine demonstrated that if the roots could be ground up fine enough there was no reason why they should not form part of the fuel and, therefore, in designing the excavator-element for the Peat Committee, the idea was kept in mind that everything excavated would take part in the formation of the final product.

The cutting hoops which form the new feature of the Committee excavator serve two purposes: first, as they are spaced closely together, no large roots can be taken up; and second, since the knives move rapidly, only a small bite can be taken by any one knife. The edges of the hoops are sharpened and many of the roots are actually cut up by the excavator. In the original design the cutting hoops were made by welding steel bars to make the desired shape but, although the first excavator proved the efficiency of the design, the cutting hoops were not strong enough to stand up in continuous operation. The tip of the hoop would catch on a root and bend and this would narrow the chain and cause it to run off its driving sprockets. Replacing bent or broken hoops was a source of constant

delay. After considerable experimentation with different designs, stronger, and entirely satisfactory knives were cut from boiler plate and bent to shape so that instead of daily delays from this cause, only two cutters were replaced during the entire season of 1922.

The excavating element as originally designed, also possessed a second defect which was not wholly eliminated until near the end of the investigation. In this first design inadequate provision was made to take care of the wide thrust of the excavator buckets. Owing to the excessive wear on the heads of the rivets holding the chain together the pins came out thus permitting the chain to fall apart. Rubbing blocks were tried out with a certain amount of success but the ultimate solution of the difficulty was obtained by installing a replaceable rubbing bar which engaged a considerable part of the cutting knives which were increased in area at the base for this purpose. A season's operation, after this change had been made, caused inappreciable wear. In the new excavator these refinements of design have been made, so that should a repair be necessary it will be possible to install a new knife in a fraction of the time required formerly.

The frame of the excavator used in 1922 although a great improvement on the first Anrep machine was still cumbersome, heavy and expensive to build. This was due to making the necessary provision for the power plant and macerator and was further aggravated by the changes in design when the caterpillars were enlarged and when the new swing hammer mill was installed. As originally designed the No. 1 excavator was not able to deliver all the raw peat which was required for Plant No. 4. As the investigation proceeded, however, its capacity was increased, and in the re-designed excavator of the new machine recommended by the Committee, although the weight has been cut in half, both excavator buckets and conveyers have been enlarged, so that it is confidently predicted that the machine as re-designed will considerably exceed the capacity claimed for it.

Macerators

The most important operation in the entire process of manufacture of air-dried machine-peat fuel is the pulping of the raw peat, since on the thoroughness with which this is performed will largely depend the density and firmness of the finished fuel and its water-shedding properties. By this operation, when properly conducted, the fibres, stems and pieces of wood, which are often found scattered throughout the bog, are cut, torn or ground into small particles, the structure of the peat is destroyed, and the peat composing the different layers of the bog is thoroughly intermixed with the colloidal substance of the peat. This produces a uniform and homogeneous mass, which owing to the high water content of the peat has the consistency of soft mud.

The better and more thorough the pulping of the raw peat, the greater and more uniform will be the shrinkage during drying. Since the density of the fuel is largely dependent on the degree of shrinkage which takes place in drying, the efficiency of the pulping operation directly affects the quality of the fuel produced.

The thorough mixing of the fibrous portion with the gelatinous contents of the peat is also of great importance, since the cohesive properties of the gelatinous matter can only be fully effective when brought into intimate association with the fine particles of fibrous matter. The firmness of the fuel produced, and its resistance to disintegration by handling, therefore, also largely depend on the thoroughness of pulping.

During the drying stage the gelatinous content of the peat performs another very important function; not only does it serve to bind the particles of the peat together, but it prevents the peat blocks from re-absorbing moisture when the drying period is interrupted by wet weather. This waterproofing of the peat blocks is due to the fact that the colloidal substance forms a skin covering the outside of the block, and this skin always assumes a state of saturation. Hence it acts as a vehicle for conveying the moisture from the inside of the block to the atmosphere. The moisture evaporated from the outside of the block by the heat of the sun is immediately balanced by moisture drawn from within. This equilibrium is always maintained until drying is complete. When rain falls on the partly dried block it quickly brings this skin to its maximum saturation, in which state it sheds water freely and prevents it from penetrating into the interior of the block. Maximum efficiency of this protective effect is obtainable only by thorough pulping. When drying takes place under cover, or in the open during long continued dry weather, sods of raw peat cut from the bog, will dry more rapidly and to a greater degree than pulped peat from the same deposit. But cut peat on account of its porous spongy texture readily absorbs any rain falling on it, and during prolonged wet weather may become so saturated throughout as to return to its original moisture content. Under ordinary drying conditions in the open, the drying of cut peat is thus subject to serious set-backs by every rainfall, and in a very wet season it cannot be successfully air-dried.

Investigations conducted in Ireland in 1919 and 1920 showed that, under ordinary field conditions, machine-peat dried more rapidly than cut peat, and that machine-peat can be dried under conditions less favourable than those necessary for the drying of cut peat.[1]

The machines hitherto employed for pulping peat usually consist of a cylindrical shell inside of which is a set of spiral rotating knives, and a set of knives fixed to the inside of the cylinder. The material fed through a hopper is forced by the spiral knives rotating against the fixed knives. The Anrep macerator is a typical example of these machines. (Figure 20).

When the Peat Committee began its investigations there were a number of pulping machines manufactured in Europe, but none which appeared to be superior to those of the Anrep type. As these machines had been long in commercial use in Europe, it was not anticipated that any difficulties would be experienced in this part of the operations. Arrangements were, therefore, made for the construction of two large-sized machines, one for the Anrep plant and one for the Moore plant. An Anrep pulper, such as described, had been used in the demonstration plant operated by the Mines Branch at Alfred in 1910 and 1911. Two similar machines had

[1] The Production of Air-dried Peat, Report of the British Fuel Research Board for the years 1922, 1923.

been employed by private parties operating on the Farnham bog, and an enlarged machine (Figure 21) had also been used by the Canadian Peat Company at Alfred in 1914. None of these machines, however, had been subjected to a real test under continuous maximum operation.

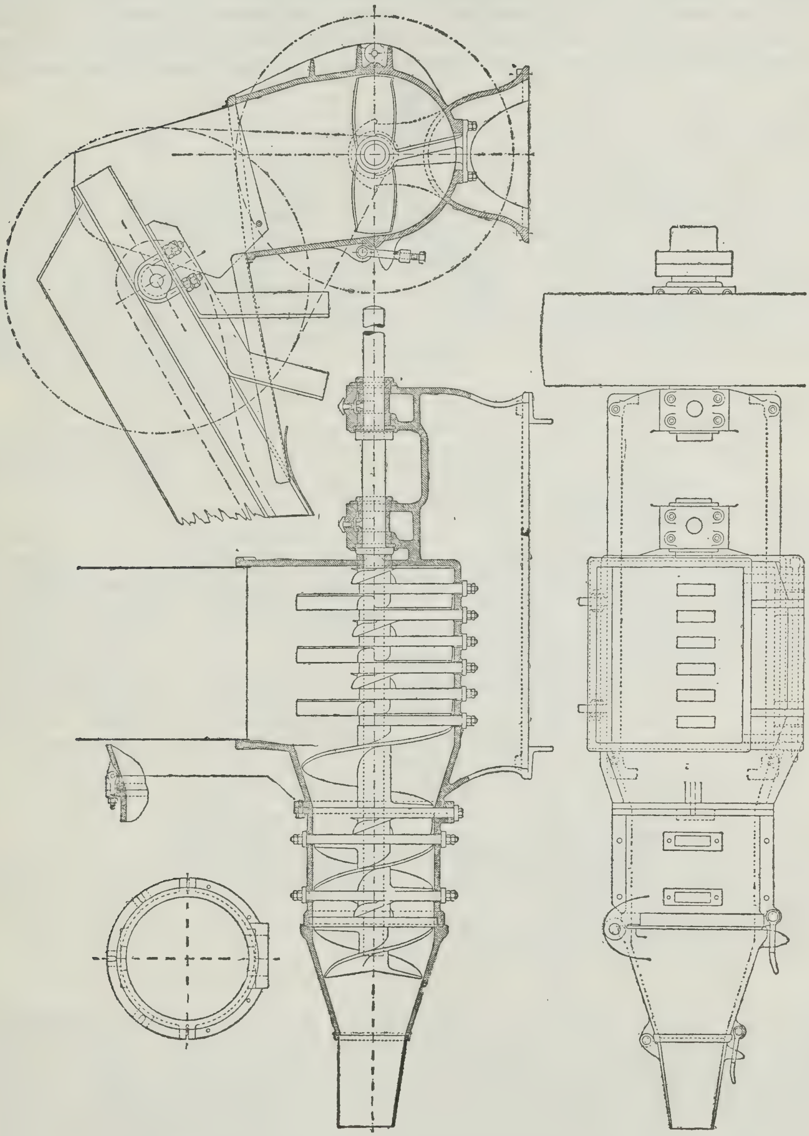


FIGURE 20. Anrep macerator, original design

When the new machines were installed at Alfred they operated with a fair degree of efficiency. During the 1920 season, when operation became more regular and continuous their efficiency rapidly decreased, and many delays were caused by the machines plugging up with roots and fibres. The primary cause of this failure was the wearing of the knives so that the rotating and fixed knives did not come properly in contact, nor could this defect be remedied by adjustment. After a few weeks of steady operation, instead of cutting the roots and fibrous peat the knives simply bruised them, and hardened accumulations of these materials were formed in the machines,

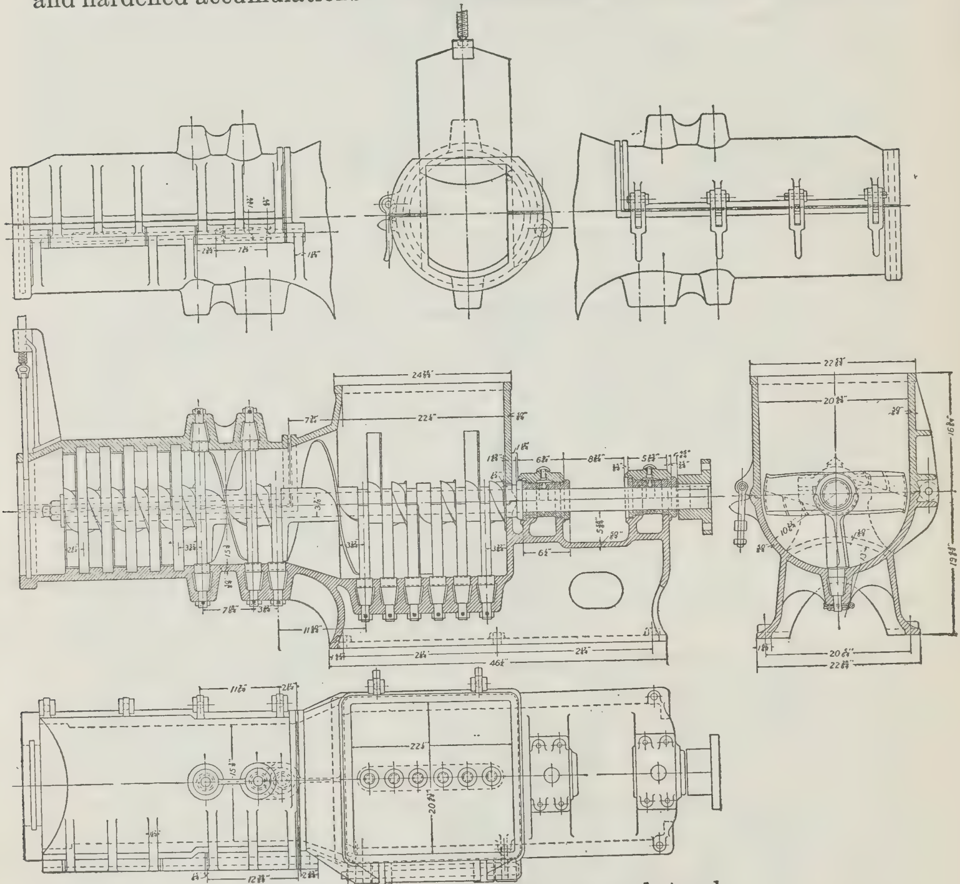


FIGURE 21. Anrep macerator as re-designed

which had to be removed with chisel and hammer. This contributed largely to the reduction in the efficiency of the machines. Before commencing work in the following year the working parts of both machines were renewed, the cutting knives being divided into two halves, which could be easily removed and replaced as they became worn. As originally constructed, according to the standard designs, the knives were inaccessible without such dismantling of the machine as led to a very considerable loss of time.

Although some improvement was effected by the alterations made, operation of the machine in connexion with the Moore plant in 1921 continued to be more or less unsatisfactory, and owing to delays caused by breakages and stopping to replace knives, and to more or less plugging of the machine by roots and fibres as before, the capacity could not be continuously maintained to produce the output for which it was designed.

Jeffrey Swing Hammer Shredder

At the conclusion of the demonstration of the two types of peat machines, under practically commercial conditions, the results obtained showed that a machine in order to manufacture peat fuel on a commercial basis must have a large daily capacity. Although the capacities of the two machines were estimated to be 10 tons per hour each, in actual practice an average of about 6 tons per hour was all that could be realized. In designing the combination plant, therefore, the efforts of the designer were centred on the development of a machine which would be capable of producing an hourly average of 10 tons of saleable standard peat fuel throughout a season of 1,000 hours, irrespective of weather conditions and ordinary stoppages.

A capacity of 10 tons of saleable peat fuel per hour for 1,000 hours necessitates the maceration or treatment of much larger quantities of raw peat substance than the well-known types of macerators such as the Anrep are capable of handling. To obviate the designing, construction, and trying out of an enlarged Anrep macerator it was at first decided to employ two of the largest-sized Anrep macerators in parallel—which would give double the capacity of the single macerator theretofore employed. But it was found that two macerators could not be properly installed on the platform of the Anrep peat machine. The Peat Committee, therefore, sought other means for carrying out this operation in the manufacture of peat fuel. About this time their attention was directed to the possibilities of a swing hammer shredder for macerating peat. A Jeffrey swing hammer shredder had been employed for pulping kelp on the Pacific coast in the U.S.A., and the results obtained in treating that material were considered of such importance that the Committee made arrangements to procure a swing hammer shredder for experimental purposes. Through the courtesy of the Jeffrey Manufacturing Company of Columbus, Ohio, the loan of one of their Type A shredders was obtained. This was installed and given several trials, the results of which were so satisfactory that the shredder was purchased and installed on the combination plant (No. 4) for macerating the peat in place of the Anrep macerator. Figure 22 shows plan, elevation, and section of this shredder. It consists of a shell A, with a hopper B, provided with a striking plate C, and a series of bars D. Hammers F, free to swing on a pivot G, are mounted on a drum E. These hammers can be partly seen on the plan. The drum rotates at a speed of about 1,200 r.p.m. The peat which is fed through the hopper E is reduced to a homogeneous pulp by the impact of these hammers against the striking plate C. The material which has been thoroughly pulped passes through the opening between the bars D. The material which has not been thoroughly pulped remains on top of the bars and is carried back by the hammers against the striking plate, and in this manner receives further maceration.

When this machine was employed for treating peat with 90 per cent water content, it was found that the openings between the bars became clogged, and as a consequence the power required for operating the mill rapidly increased, and the capacity of the mill was reduced. In order to increase the capacity and reduce the power required the mill was run with every alternate bar removed. Owing, however, to the construction of the mill and the manner in which these bars were placed, it was found that this was not practicable. A trial was, therefore, made with all the bars removed, in order to ascertain the degree of maceration which the peat would receive under these conditions, the power required, the capacity, and the effect that the bars had on the maceration of the peat. The capacity was greatly increased, the power for operation materially reduced, and although the peat did not receive as thorough a maceration as when the bars were in place, the maceration which it did receive was still superior to that obtained with the Anrep macerator and was considered satisfactory. The mill was, therefore, used throughout the remainder of the investigation, with the bars removed.

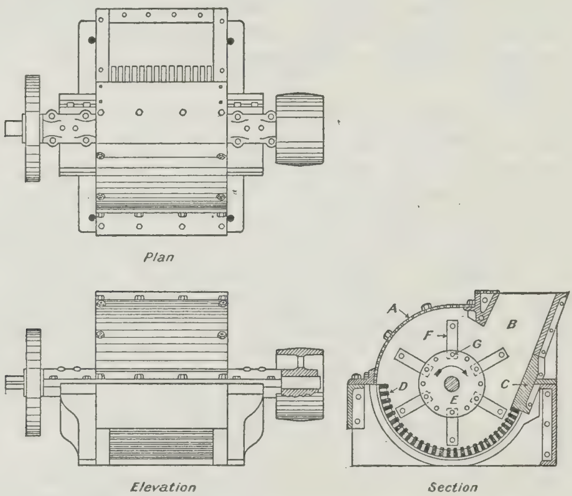


FIGURE 22. Jeffrey swing hammer shredder

The outstanding advantages which this mill possesses over the Anrep macerators, is its ability to clear itself, without breaking, of solid matter such as bolts, stones, etc., and the efficiency with which it shreds pieces of wood excavated with the peat, and which, in the old type of macerator, caused considerable delay due to stoppages from clogging.

Spreaders

The raw peat after being pulped may either be conveyed direct to the drying-ground and spread on the surface in a layer of suitable thickness, which is afterwards divided into blocks of the required size, or it may first be passed through a forming machine which moulds and cuts it into blocks which are conveyed to and laid out on the surface of the drying-area. In most European plants the peat blocks are moulded before being spread upon the ground.

A method commonly employed in small European plants is to receive the moulded peat as it issues from the mouthpiece of the machine on short lengths of board or pallets which are loaded by hand on small trucks, provided with shelves. These are then pushed to the drying-ground, the pallets removed, and the peat blocks dumped on the surface of the bog, while the boards are returned to be refilled.

Persson's conveyer receives the loaded pallets automatically on two parallel cables by the motion of which they may be conveyed to a distance up to 200 metres from the machine, and from which they are removed by hand, and the peat tipped on the drying-surface by men stationed along the conveyer cables.

By the more fully automatic machines of the Wielandt, Baumann-Schenck and other types, however, the moulded peat blocks as they issue from the machine are deposited on a moving chain of tilting-plates which carry them as far as 40 to 100 metres from the working-face, and, when the entire length of the chain of plates is filled, automatically tip them on the ground. Machines of this type are all somewhat open to the objection that the wet peat blocks when dropped on the surface from even a distance of a few inches are apt to be badly distorted giving an unsightly appearance to the finished fuel, and tending to increase loss through fines in subsequent handling.

In some recent installations in Europe under what is known as the hydro-peat process, the peat pulp in a semi-fluid state is pumped to the drying-ground through a pipe line and allowed to spread over the surface within limits fixed by dykes.

The method selected by the Committee as likely to be most suitable for use in developing Canadian bogs is that first mentioned above, viz.: the transportation of the peat pulp to the drying-ground to be spread and subsequently formed into blocks.

The peat pulp spreading-devices generally employed in Europe are of the field-press type. They consist essentially of a bottomless box with means for distributing the peat evenly across its width, and for moving it along the surface of the bog. The peat dumped in the box is deposited directly on the bog surface, and by the movement of the box the surface of the peat mass is levelled and it is evenly spread to the required depth. To divide it into blocks the layer of peat is cut lengthwise and crosswise by disks and knives, either mechanically or by hand.

All spreaders of this type are open to the objection that while the top surface of the peat layer is even, the bottom surface follows any irregularities or depressions in the surface of the bog, so that the thickness of spreading is subject to very considerable variations. Instead of obtaining a uniform thickness of $4\frac{1}{2}$ to 5 inches, depressions may be filled to a depth of 10 to 12 inches or more, while the peat on high spots is not more than 1 or 2 inches thick. This leads to unequal drying, which is a serious drawback to harvesting operations, and destroys the uniformity of the fuel produced.

For the purposes of the investigation, a spreader of the field-press type, according to plans of the late Aleph Anrep, was built and installed as a part of the working equipment of Plant No. 1. Motive and operating power was supplied from a gasoline engine mounted on the front of the spreader, which rotated two large independently driven rollers by means of which the machine was moved ahead.

Mechanical difficulties in operation were met with from the outset. The spiral provided to distribute the peat evenly across the width of the spreader failed to work satisfactorily. The cutting knives, which were long metal strips trailed on edge behind the press, to divide the peat into longitudinal strips, did not perform their function properly. Moreover the machine was very difficult to steer.

Before the season of 1920 a new spreader was built to overcome these difficulties, steel being substituted for wood in the general construction. Plate XXVII illustrates the machine in operation. The tractor element in the new machine was so installed that it could revolve around its own centre without moving the main frame of the machine, and in this way it was possible to turn the spreader around practically in its own length. Properly spaced disks arranged on a light steel axle trailed behind the machine were substituted for the cutting knives.

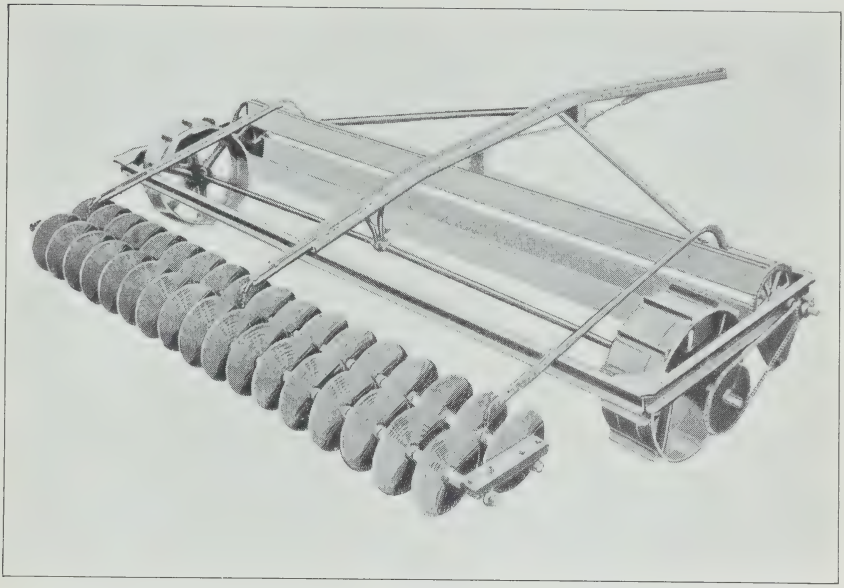
There remained another type of pulp spreader to be investigated, viz.: that in which the peat, instead of being deposited directly on the bog surface, is dumped into a closed box and, by the operation of spirals operating therein, is forced through an opening at the rear of the box and close to the ground. From this opening the pulp issues in a layer of the required thickness and of the width of the spreader, and is laid gently on the bog surface without any pressure other than that of its own weight.

A small spreader of this type had been constructed and operated for a short time in connexion with a portable peat plant built at Farnham, Que. An attempt made at Alfred, in 1914, to improve on the spreader used at Farnham by substituting for the long narrow opening or mouthpiece of the machine, a row of multiple spouts by means of which the peat would be actually moulded as it was spread, was a failure. In operation the peat fibres adhered to and accumulated on the dividing partitions between the spouts, quickly clogging them and necessitating frequent stoppages to clean out the passages.

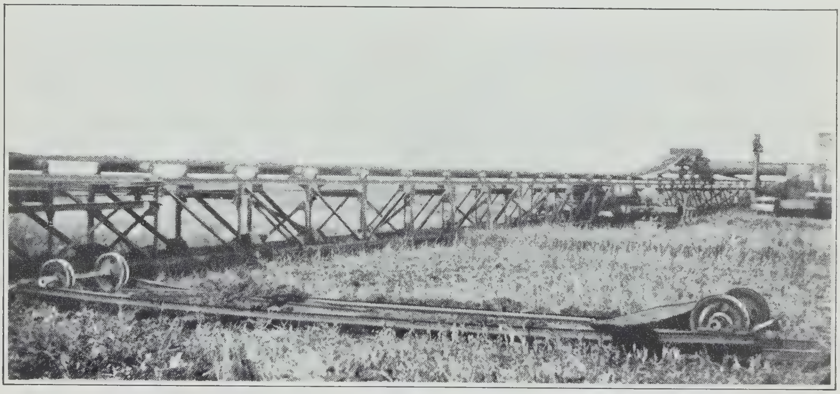
Plant No. 2 was equipped with a spreader of the closed box type which gave very fair satisfaction in operation (Plate XXXII). Construction was simplified in this case owing to the fact that motive power for operating was supplied from the main plant through a shaft mounted on the bridgework of the conveyer to which the spreader was attached.

The spreader box was carried on light caterpillar elements which were driven from the shaft by means of a chain belt and sprocket. For cutting the peat longitudinally, instead of a single axle bearing disks 5 inches apart, two shafts with disks 10 inches apart, and so arranged as to make uniform cuts at 5-inch distances, were used. With the narrower spacing on a single shaft, there was a tendency for the peat pulp to cling to the disks, leading to clogging and some distortion of the blocks, a difficulty which was entirely overcome by the arrangement just described.

The main defects in operation of this spreader were due not to any fault of the spreader itself but to the manner in which it was operated. Being attached to the bridgework of the conveyer its movement and rate of travel were entirely dependent upon the forward movement of the conveyer and excavating element. It had therefore no flexibility of movement which would enable it to overcome the effect of uneven feeding of



Cross and longitudinal cutting-device with—Plant No. 4



Plant No. 4—truck for shifting spreader

thus be considerably lightened. Caterpillars of standard design and of an improved type will be employed to carry the spreader and for the present cumbersome cutting device, knives and disks will be mounted directly on both sides of the spreader, which can be raised when not in use, thereby obviating the employment of manual labour in turning at the end of the row. Time occupied in turning will also be further reduced by the new machine. With Plant No. 4 an average length of time of 10 minutes was required for each move ahead of the belt conveyer, including the time for moving the cutting device by hand. The elimination of the latter operation should reduce this to about 5 minutes, which would effect a saving of over half an hour in a 10-hour day.

The water content and consistency of the peat slop have an important bearing on spreading. Where the peat is pre-moulded as in European practice, the slop must be comparatively dry to permit the forming of blocks, and to avoid too great distortion of these when dumped on the drying-ground. Where the slop is spread directly on the drying-area it can be handled with a higher water content, the only requirement being that it must be of such consistency as to stand up when cut on the bog surface. The average water content of the peat slop spread at Alfred was 90 per cent, and this was found to be about the most satisfactory condition for spreading. When the water content fell as low as 87 or 88 per cent the operation of the machines was more difficult and their capacity was lowered. The disadvantages of spreading peat of high water content are the greater volume of material which must be handled, and the greater area of the drying-field which must be covered for a given production of fuel. These are in practice, however, more than offset by the lower power required, the easier working and greater efficiency of the machines, and the greater firmness of the fuel produced, when slop containing as high as 90 per cent water is spread.

Harvesting of Fuel

The picking up of the fuel from the drying-field and its transportation to storage or point of shipment, constitutes one of the most important factors affecting the economic production of fuel from peat by the air-drying process.

Any gains resulting from the use of more efficient machines for excavating, pulping, and spreading the raw peat may easily be offset by inefficient and costly methods of handling the manufactured fuel.

As already stated when peat slop with 90 per cent water content is spread 4 inches deep in a row 12 feet wide, about 56 linear feet of row must be laid to yield a ton of air-dried fuel with 30 per cent moisture. To spread 1,000 tons will, therefore, require an area of $56 \times 12 \times 1{,}000 = 672{,}000$ square feet. Assuming the rows to be 800 feet long, and a space of about 1 foot to be allowed between rows, the area covered will be in the vicinity of 800 $\times 900$ feet. Also, since the peat blocks will average about 1 pound in weight each, approximately 2,000 pieces must be picked up to each ton of fuel produced.

The problem of designing a machine to automatically pick up the fuel from the bog surface presents serious mechanical and practical difficulties. An experiment was made at Alfred, in connexion with the operation of

PLATE XLVI

Peat spread on the field, at Alfred, as it appears when partly dry

PLATE XLVII

By permission of the Controller of H.M. Stationery Office.

Peat as laid on the field by Dolberg sod-transporter

Plate XLVIII

By permission of the Controller of H.M. Stationery Office.

Peat as laid on the field by Siemens sod-transporter

Plate XLIX

By permission of the Controller of H.M. Stationery Office.

Peat as laid on the field by Wielandt sod-transporter

Plant No. 2, employing two sections of a spiral conveyer encased in a hood. When these were rotated on the bottom plate of the hood and drawn along sideways in contact with the surface of the bog, the peat blocks were propelled towards a conveyer trough, located centrally between the ends of the two spirals, which had its sides cut away to permit the delivery into it of the fuel picked up by the spirals. The trough itself was equipped with a conveying device consisting of cleats on an endless chain, and was inclined at the farther end to elevate the peat and deliver it on the belt conveyer for transportation to cars. The conveyer trough which is shown in Plate XXXII was also employed separately, the peat being fed into it by hand by men equipped with coke forks. For the experiment mentioned the lower shaft at the rear end of this device was lengthened for 6 feet on each side, and the spirals were mounted on the projections. Owing to lack of power no extended tests of the apparatus could be made. Since the action of the spirals working against the edge of the hood tended to plane off all inequalities on the surface of the bog, a very level drying-field with even surface would be required for its operation, and this would necessitate the removal of many roots and small stumps which could otherwise remain in the surface of the bog without injuring it for spreading purposes. Under existing conditions a great deal of dirt was gathered up with the harvested peat. The portion of the row covered by the conveying trough still had to be cleared by hand with forks. No measure of the power required for operation was obtainable.

In picking up the fuel with forks two factors materially affect the cost of the operation, viz., the distance which it must be carried to carts or cars to be loaded for transportation, and the labour involved in raising the material to the top of the conveyance. The tops of the small open cars used for transporting peat on the bog at Alfred were approximately five feet above the surface level.

With ordinary hand-winning methods practised in Ireland, the peat is gathered into large wicker baskets, and carried to stacks by two men for distances up to 50 yards. Even where automatic excavating and transporting plant is used in Germany, the peat is collected and carried in a similar manner and stacked outside of the drying-ground.

In order to minimize as much as possible the labour involved in these operations, a power-driven, self-propelled harvesting conveyer was designed and built in the summer of 1920, and after a thorough try-out was rebuilt and enlarged in 1921. (Plate XL.) This machine was essentially a steel trough about 55 feet long, 30 inches wide and 6 inches deep with one end turned up high enough to be well over the top of the harvesting cars. The trough was supported about 8 inches above the bog surface on two small caterpillar elements, one at either end, and a pair of rollers in the centre, and contained a double chain and flight conveyer, by which fuel forked into the trough was carried along and elevated so as to discharge directly into the harvesting cars. Power to run the conveyer and move the machine was supplied by a 6 h.p., type Z, Fairbanks-Morse, gasoline engine.

In operating the harvester (Plate L) a portable harvesting-track was laid between two rows of peat on the field, and the harvester moved sidewise under its own power alongside and parallel to the track, spanning about three or four rows of peat according to the spaces left uncovered between rows. Steering could be easily effected by throwing either of the caterpillars out of gear. The portable, steel tracks used in harvesting were laid directly on the surface of the bog, and were constructed in sections about 16 feet in length which could be easily handled by two men. The workmen walked behind the machine, and lifted the peat into the trough with coke forks. Seven to ten men were required for this work, besides a foreman, a man levelling the cars, and a boy operating the small tractor which hauled out the loaded cars and placed empties to be filled.

On completion of the rows, the machine turned under its own power, one of the caterpillars being run on a small metal turn-plate and thrown out of gear, while the others described a half-circle, and harvesting of the next three or four rows proceeded in the opposite direction. Spaces were provided between the rows at suitable intervals to permit of the laying of the tracks as harvesting proceeded. On arrival at the starting side of the drying-ground the harvester moved across to the next four rows and repeated the operation as above described. A very marked saving in the labour cost of handling peat fuel from the field was effected by this machine. When in regular operation a small car carrying on an average $1\frac{1}{2}$ tons of fuel, could be loaded in about four minutes. This rate of working could not, of course, be maintained continuously, owing to the time lost in turning at the ends of the rows, and in laying new tracks, and also in the hauling of cars to and from the harvester.

Considerable improvements on the conditions of operation as they existed at Alfred could be readily made. The harvester was geared only for the slow speed necessary in operating. By providing a high second speed the time lost in turning at the ends of rows could be materially reduced. Time could also be saved and cost reduced by providing two men to move tracks, who would always have one track ready in advance. Tracks of 24-inch gauge were used, and delays occurred frequently from cars running off the track owing to the very narrow gauge, and the very short wheel base. Increase of the gauge to 30 or 36 inches, with corresponding modification of the cars would greatly lessen delays on this account.

Finally, owing to conditions at the loading-platform, the harvester was from time to time held up for considerable periods waiting for empty cars. Despite the drawbacks mentioned, however, very favourable results were obtained. The records of the week September 18–23 during which the harvester was in regular operation may be taken as a fair example of the actual performance of the machine.

Highest amount weighed over scales in one day.....	115	tons
Lowest amount weighed over scales in one day....	74	"
Average quantity of fuel harvested daily..........	$85\frac{1}{4}$	"
Number of men employed forking peat............	11	
Average hourly wage...........................	32	cents
Average labour cost per ton delivered on main track	55·3	"

PLATE L

Harvester in operation

Plate LI

Train of loaded cars leaving drying-field; empty cars going in to harvester

Plate LII

View of original loading trestle

Transportation, Stacking and Loading Cars

Permanent tracks were laid around the drying-area and to the railway station as shown in Figure 16. These were of 24-inch gauge with steel rails weighing 16 to 20 pounds to the yard, and were laid on short, wooden ties. Three trains of 8 cars each were employed (Plate LI) so that one train was in transit, one loading, and one unloading at the same time, each car having a capacity of about 3,000 pounds. Hauling was effected by a small Plymouth gasoline locomotive.

The loaded cars were hauled between $1\frac{1}{2}$ and 2 miles to Alfred station, and the peat weighed, screened, and loaded directly into railway cars. Four men at the loading station and a boy operating the tractor were required for this work. The average hourly wage was 35 cents and the average labour cost per ton for transportation and loading on railway cars was 20·5 cents making a total labour cost per ton of 75·8 cents from drying-field to railway car. This figure could be considerably reduced under more favourable conditions of operation. Whenever railway cars were not in readiness to be loaded the peat was weighed and dumped on an adjacent storage pile without screening. This necessitated a re-handling to railway cars later on, involving an additional expenditure for labour.

In the early part of the investigation when it was anticipated that work would not be continued for more than two seasons, a temporary wooden trestle for storage and loading was built at Alfred station (Plate LII). The loading trestle, 22 feet in height, was erected parallel to the railway siding with an inclined approach up which the cars were hauled by a cable operated by a steam-hoist. The cars passed over a platform scale before going on the trestle, and accurate records of the weight of peat brought from the drying-field were kept. When loading for shipment the harvester cars were dumped directly into the railway cars from the top of the trestle, the fuel first passing over a screen of parallel bars set at an angle of 45 degrees, and the fines being deflected by a chute underneath the trestle.

To provide for storage a second trestle was built at right angles to the loading trestle. When the storage pile became large enough tracks were laid from the trestle out on to the pile itself and in this way the size of the pile could be increased indefinitely.

Late in the fall of 1921 these trestles were partly destroyed by fire which consumed the greater part of the fuel then in the storage pile. Plans for better handling of the finished fuel had already been under consideration, and it was decided, since a certain amount of material from the dismantled Plant No. 2 was available, to erect a portable all-steel, loading and storage conveyer.

Loading and Storage Conveyer

The remains of the original trestles were, therefore, removed and replaced by the structure shown in Plates LIII and LIV. The new equipment comprised a movable belt conveyer and a Barber-Greene loading elevator, with a 10 h.p. gasoline engine to supply power for operation, rails on which to move the machines, and light narrow gauge tracks for handling cars to and from the loading device. The belt conveyer which was about 175 feet long, consisted of a 14-inch rubber belt carried on rollers mounted on a steel framework which extended at right angles to the railway siding and was supported at three points in its length, at a height of about 13 feet. The supports were carried on wheels, resting on rails laid parallel with the railway track, which permitted the entire structure to be moved sideways from one end to the other of the storage area. At the end next the railway the belt was carried over a movable framework which could be extended to project over the centre of a car when loading, and drawn back beneath the main framework to provide clearance for switching cars.

The Barber-Greene elevator was of the ordinary wagon-loading type but with an elevator-arm 54 feet in length by means of which the peat was elevated to the top of the conveyer. It was also supported on wheels permitting it to be moved back and forth along the siding with the belt conveyer.

A 10 h.p. gasoline engine supplied power to the conveyer and also drove a shaft, installed along one side of the conveyer, from which power was taken for the elevator. The elevator could, therefore, be operated in any desired position in the storage-field.

In operation, the harvester cars were dumped into the hopper of the elevator, which delivered the peat to the belt. The belt drive was reversible and when cars were being loaded the movable frame was pulled out into position and the belt driven to carry the fuel forward. On its way to the car the fuel dropped 30 inches from the top of the drive pulley to the extended part of the belt, and where this drop occurred a series of bars were installed as a screen. The fuel passing over these bars was conveyed to the railway cars, and all the fines which dropped through the screen were deflected on the return side of the belt and carried to the outside end of the conveyer where they were dumped in a separate pile (Plate LIII). When it was desired to store the fuel, the direction of the belt travel was reversed, and the fuel deflected from the belt by means of a plough which could be shifted to any desired position on the belt. By means of shifting the plough, and moving the conveyer on its carrying tracks, piles of fuel 15 feet high and of any desired length and width could be deposited anywhere over the storage-field.

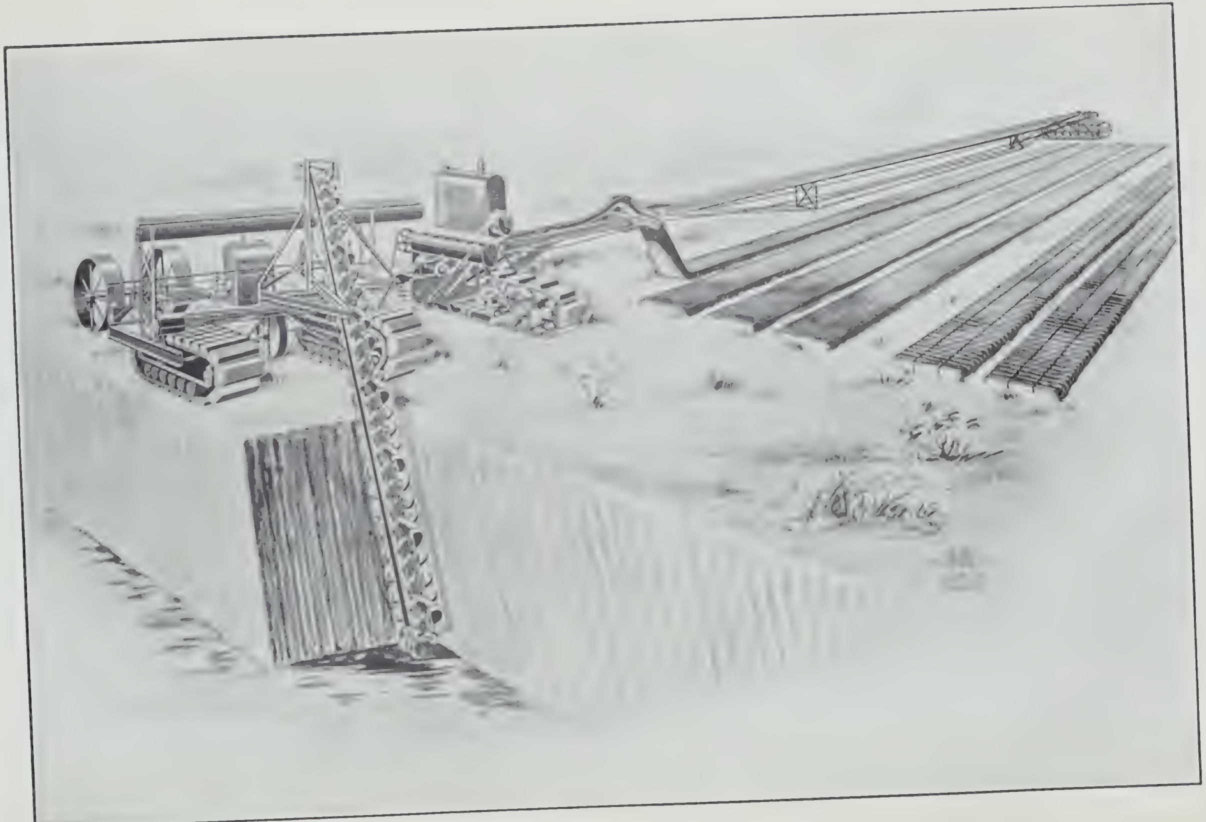
As installed, the conveyer although designed for a 20-inch belt, was equipped with a 14-inch belt from the dismantled Plant No. 2. By placing a narrow, wooden strip along each side of the belt to hold the peat on it a capacity of loading 10 tons per hour was obtained, and this would have been materially increased by using a belt 20 inches wide.

Plate LIII

View of loading and storage conveyer showing elevator

Plate LIV

View of loading and storage conveyer



Plant No. 3—final design

Production and Sale of Fuel

The primary objectives of the investigations conducted by the Peat Committee were the development of machines adapted for the manufacture of peat fuel on a commercial scale and the study of the physical and other conditions affecting the successful carrying on of manufacturing operations. Actual manufacturing operations were subject to frequent interruptions due to alterations being made in the machines or to experimental work in trying out various devices. The production of fuel was therefore largely incidental, and not carried on under commercial conditions. During the investigation between 16,000 and 17,000 tons of fuel were laid down on the drying-field, viz.: in 1919-20, 2,600 tons; 1920-21, 5,500 tons; 1921-22, 4,000 tons; and 1922-23, 4,700 tons. Part of the fuel made in experimental working was not of marketable quality, and part was used to supply power for operating the plants. More than half of the total fuel manufactured during the season of 1921 was destroyed by fire which consumed the peat in storage. About 8,500 tons of fuel were sold, and over $40,000 was realized from sales. Of the total production, 4,800 tons were made by Plant No. 1, 7,300 tons by Plant No. 2, and 4,700 tons by the combination Anrep-Moore Plant No. 4.

CHAPTER VIII

GENERAL OBSERVATIONS AND CONCLUSIONS OF THE COMMITTEE

PROTECTION OF THE BOG

Effect of Frost on the Working-face

Under the severe winter climatic conditions in many parts of Canada, exposed working-faces are penetrated by frost to a considerable depth, 18 inches or more.

Because of the poor heat conductivity of peat, frost is retained in the exposed surfaces of a bog until late in the spring. This seriously militates against the efficient operation of those peat-manufacturing plants that require a long working-face, inasmuch as the commencement of operations may in consequence be seriously retarded. On account of the shortness of the season during which manufacturing operations can be conducted, and the fact that the early part of the summer is more favourable for drying peat, every day gained is of great importance.

Types of peat-manufacturing plants, on the other hand, that require a short working-face (in virtue of the method of excavating employed viz.: excavating back and forth across a working-face only a few yards in width) are much less liable to delay, due to frost, as it is a simple matter to free the working-face of frozen peat, and once this is done only the extreme outer end of each cut made across the working-face is affected by frost. As the depth of each cut is only a few inches the small amount of frozen material to be handled is not a serious matter.

A still more important consideration, however, is the effect of frost on peat as a raw material for fuel. Exposure to extreme cold destroys the colloidal character of raw peat. Wet peat, when frozen, loses its cohesive properties and capacity for shrinkage in drying. Fuel blocks made from it develop cracks at an early stage in drying, and crumble to pieces when dried to a moisture content suitable for their use as fuel.

In the case of the Moore plant (Plant No. 2), which excavates a thin slice along a long working-face, the peat dug during the first few cuts made in the early part of the season will not be suitable for the manufacture of fuel, for the reasons set forth above.

A considerable portion of frosted peat, however, may be mixed with peat which has not been frozen without causing any apparent deterioration in the quality of the product. The small quantities met with in operation of a plant of the Anrep-Moore type, therefore, are in no way detrimental.

Where the drainage of the bog can be readily controlled, the working-faces may, to a large extent, be protected from frost, by allowing the excavation to fill with water after closing down operations in the fall. The surplus water can then be drained off early in the spring before work commences.

Effect of Burning the Bog Surface

The covering of small shrubby growth, mosses, etc., existing on most bogs, serves to protect the humified peat from deep surface penetration by frost. Its removal by burning, therefore, is a detriment.

Such growth also serves as a mat or cushion which greatly facilitates the moving of the heavy machines employed. Areas where the surface has been burned off are soft, and are apt to occasion delays and difficulties in operation through sinking of the machines.

Finally the presence of burned spots in the area employed as a drying-ground, is a serious drawback to the drying of the fuel. The protective covering, containing numerous air-spaces, prevents direct contact between the macerated peat laid on the surface, and the wet peat beneath, and thus greatly facilitates drying. Where the surface has been burned, the wet peat slop spread on the surface constantly receives moisture from underneath by capillary action, and drying is consequently seriously retarded, and in some cases suspended.

It is, therefore, of great importance to protect the bog surface from destruction by fire. Fires are very easily started during the hot, dry weather of midsummer and the utmost precaution, therefore, must be exercised to prevent fires from starting and to extinguish any fire which may start, with the least possible delay.

The practice, which is common among farmers owning farms adjacent to and extending into peat bogs, of setting fires during the summer months to clear off the surface along the margin of the bog for the purpose of reclaiming additional land for cultivation, is a source of great danger to buildings and peat plants placed on the bog. During a dry season fires which get beyond control, often overrun large areas of the bog. On several occasions, during the period field operations were conducted by the Committee at Alfred, serious fires which more than once threatened the entire destruction of the buildings and plants occurred from this cause.

The practice of setting such fires is not only a menace to buildings which may be some distance from the region of the fire, but, which is far more serious, destroys, for future use, a source of fuel which at some time may be of extreme value. Steps should, therefore, be taken to discourage this practice.

Drainage and Control of Water-level

The object of draining is to provide a suitable drying-area and to render the bog surface sufficiently firm to support peat machines and transportation system. A bog should not be drained beyond this point inasmuch as the fire risk is materially increased by further and excessive drainage.

COMMERCIAL PRODUCTION OF PEAT FUEL ON A LARGE SCALE

Area Required for Operation

The limiting factor in large-scale production of air-dried machine-peat fuel is the extent to which drying of the raw peat can be effected by the natural agencies of sun and wind during a comparatively short period in each year.

The length of the season in which drying in the open air can be accomplished is governed by natural conditions and which are uncontrollable. Apart from the types and capacities of the machines employed, there are three possible ways by which increase of production might theoretically be obtained.

(1) By removal, to as great an extent as possible, of free water from the peat in the bog by drainage, thereby reducing the volume of water to be evaporated per ton from the material excavated.

(2) By increasing the depth of the layer of peat laid out to dry.

(3) By extending the area of the drying-ground on which macerated peat is spread.

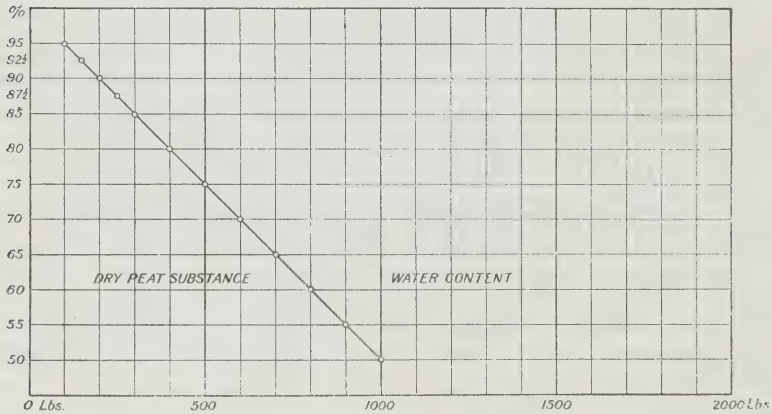


Figure 23. Curve showing amount of water and dry substance in 2,000 pounds raw peat with moisture contents varying from 93 to 50 per cent

(1) The first of these methods is at first sight the most promising. The peat in an ordinary undrained bog has a water content of 90 per cent or upwards. With a water content of 90 per cent each ton of raw peat excavated contains 1,800 pounds of water and only 200 pounds of dry peat substance. In order to produce a ton of peat fuel with 30 per cent moisture content, 7 tons of the raw peat must be excavated and 6 tons of water evaporated or separated by other means. If it were practicable to reduce the water content of the raw peat to 75 per cent by draining

the bog, each ton of raw peat excavated would contain 1,500 pounds of water and 500 pounds of dry peat substance. The amount of raw material to be handled to produce a ton of peat fuel with 30 per cent moisture would be only 2·8 tons and the amount of water to be removed by subsequent evaporation on the drying-ground would be reduced to 1·8 tons. The accompanying curve (Figure 23) shows the amount of water and dry peat substance contained in 2,000 pounds of raw peat with moisture contents varying from 93 to 50 per cent.

Experience at Alfred, however, clearly demonstrated that the removal of large quantities of water from the raw peat by drainage is not practical. The quality of the fuel produced depends on the amount of shrinkage in drying, and to obtain dense, firm blocks of fuel, the macerated peat spread on the field must contain a high percentage of water. Experiments showed that when the peat slop contained an insufficient amount of water the peat blocks checked in drying, and disintegrated in handling, producing a fuel of inferior quality. The best results were obtained when the peat slop spread on the field had an average water content of about 90 per cent.

Drainage of the bog to about 87½ per cent water content produces a surface sufficiently firm to carry the machines. Once this object is attained, further drainage can serve no useful purpose, since water must then be added to the peat to produce a peat slop of the proper consistency to yield a fuel of high quality.

(2) If it were practicable to deposit the peat slop on the drying-ground in thick layers, a foot or more in depth, several advantages would accrue. Transportation of the raw peat to the drying-ground would be simplified and larger quantities of the raw material could be laid down in less time and at a lower cost. Both time and labour would also be conserved in the subsequent handling of the fuel on the field. The cost of turning the partly dried peat blocks and of harvesting the dried fuel are important items in the cost of production. Turning is usually done by contract at a fixed rate per 100 feet of row. The smaller the area covered per ton of fuel, therefore, the lower the cost of turning will be. The same is true of harvesting, since a shorter length of harvesting tracks is required. Less movement of the spreader, conveyer, and excavator will also be required.

The thickness of the layer of peat, however, that can be laid on the field to dry is restricted within very narrow limits by seasonal drying conditions, as is shown on page 158. As the result of experiments it cannot be recommended to spread macerated peat to a depth of 6 inches later than the early part of July. After the first week in August it may be found advantageous to spread only 4 inches thick in order to facilitate more rapid drying. The average depth to which peat should be spread in order that the same drying-ground can be used twice or more during the season is not greater than 4½ to 5 inches.

(3) Inasmuch as the extent to which drainage can be carried is limited to approximately 87½ per cent, and the depth of the spread peat slop is limited to 4½ to 5 inches, the only effective means for increasing production is the extension of the drying-area.

Area of Drying-ground Required

Repeated tests at Alfred showed that approximately 225 cubic feet of peat slop with a moisture content of 90 per cent, must be spread on the drying-field to produce one ton of peat fuel with a moisture content of 30 per cent. Assuming that the thickness of the spread of the peat is $4\frac{1}{2}$ inches, $225 \times \frac{12}{4.5} = 600$ square feet of drying-area will be required to produce one ton of 30 per cent moisture peat fuel. This area must, however, be increased to allow for losses in harvesting and screening the fuel before loading on cars, amounting to a total of 10 per cent of the finished fuel. To provide for the increased peat slop which must be spread on the field to balance these losses $600 \times \frac{10}{9} = 666\frac{2}{3}$ square feet, or approximately 670 square feet will be required to accommodate sufficient peat slop of 90 per cent moisture content spread with an average depth of $4\frac{1}{2}$ inches to produce one ton of saleable peat fuel with a moisture content of 30 per cent. To provide for the laying of tracks for harvesting the dried peat fuel, the Peat Committee, when conducting the manufacturing operations at Alfred, left every 9th row unspread. In this case the spread rows were 12 feet wide, the empty space, therefore, would likewise be 12 feet. When this area is apportioned equally among the 8 spread rows, the additional area which will have to be added for the drying of the spread peat in one row will be $\frac{1}{9}$ of the area of that row, and if the same portion of drying-area is added to the area required for laying out one ton of peat fuel, namely 670 square feet, the total area required to lay out and harvest one ton of peat fuel will be 670 + 74 or 744 square feet. Since, however, the drying-ground can be spread over twice during a season, the drying-area required for an annual production of 10,000 tons of saleable peat fuel will be $744 \times 5{,}000 = 3{,}720{,}000$ square feet, approximately 85 acres.

Width of Drying-ground

In order to avoid unnecessary transportation, thereby reducing to a minimum the cost of handling the raw material, the surface of the bog adjacent to the excavation must be used as a drying-area. The width of the area which can be advantageously used for this purpose is a question of importance. The narrower the strip adjoining the excavation, which is spread with peat, the longer must be the working-face and the travel of the excavator.

Assuming that two spreadings of 90 per cent moisture peat with an average depth of $4\frac{1}{2}$ inches are made during the season. Then with spreading-grounds varying from 50 to 250 yards in width, the length of working-face which must be developed for the employment, over a working season of 2,000 hours, of machines having respective capacities of 5, $7\frac{1}{2}$, and 10 tons per hour are shown by Table XV, and Figure 24.[1]

[1] The Production of Air-dried Peat, Report of the British Fuel Research Board for the years 1922, 1923.

TABLE XV

Relation of Width of Spreading-ground to Length of Working-face.

Fuel output tons (2,000 lbs.)		Width of spreading-ground in yards				
Per hour	Per season of 2,000 hours	50	100	150	200	250
			Length of	working-face	required (yards)	
5	10,000	7,200	3,600	2,400	1,800	1,440
$7\frac{1}{2}$	15,000	10,800	5,400	3,600	2,700	2,160
10	20,000	14,400	7,200	4,800	3,600	2,880

From this it will be seen that with a drying-area 50 yards wide the development of over 8 miles of working-face would be required for an annual production of 20,000 tons of fuel, which not only would greatly complicate the problem of making a favourable layout of the bog, but would restrict large-scale production to a few of the largest bogs.

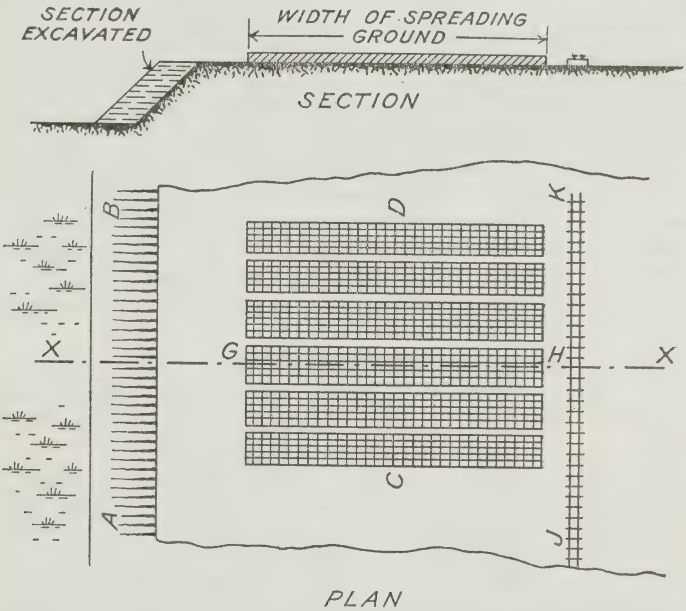


FIGURE 24. Relation of width of drying-ground to section excavated

In operation the excavator moves preferably down one side of the working-trench, is turned about the end, and returns along the other side to a point opposite the original starting point. It is then moved about the end of the trench and the operation repeated. The entire drying-area is covered at least twice during the season, and the actual length of working-trench is, therefore, one-fourth that of the total length of working-face required. The relation between the width of the drying-area and the section of bog excavated is illustrated in Figure 24.

The quantity of material which can be excavated per linear yard of the working-face AB is increased as the distance GH over which it is spread becomes greater. Conversely the less the width GH of the drying-area, the smaller the amount of the raw peat which can be excavated and spread per linear yard of the working-face AB. As the section excavated is increased the movement ahead of the excavator, for a given production, decreases as does also the length of working-face required.

Since an area of 744 square feet is required for spreading the peat slop to produce one ton of saleable fuel, the travel of the excavator for a drying-ground 150 feet wide will have to be 5 feet. This necessitates the excavation of 250 cubic feet of peat slop with 90 per cent moisture content. If the width of the spreading-ground is increased to 800 feet, the excavator will have to move ahead only 0·93 feet for each ton of saleable fuel produced. The maximum quantity of peat which can be excavated per linear foot of travel along the working-face is determined by the area available for spreading the peat slop.

Two other factors affect the operation of the excavator, viz., the depth of excavation and the width of the prism excavated. In the above calculation it was assumed that the depth of the prism excavated was 10 feet, and that the width of the prism was 5 feet. For different depths of excavation, e.g., 6 and 8 feet, the width of the prisms which must be excavated per ton of saleable fuel produced, (assuming as before the drying-ground to be 150 feet wide and the linear travel of the excavator to be 5 feet per saleable ton of fuel produced), will be 8·33 and 6·25 feet respectively. If the width of the drying-ground is increased to 800 feet, then to spread one ton of saleable fuel $4\frac{1}{2}$ inches deep, the excavator will move ahead 0·93 feet for every ton of fuel produced, assuming again that the depth of the excavation is 10 feet. If the depth of excavation varies from 8 to 6 feet the width of the prism will be 26·8 feet for a 10-foot excavation, and 33·6 and 44·7 for 8 and 6 feet respectively.

While the relation between the dimensions of the prism excavated is accurately shown, the figures must be regarded as approximations only, since the prism excavated will vary according to the physical characteristics of the peat.

In order to preserve an even working-face the width of the prism excavated must be uniform from one end of the working-trench to the other, even though the depth of the peat may vary considerably at various points along the working-face. This width of cut will be naturally restricted to that required to fill the drying-area in that portion of the bog where the deepest excavation is made. This emphasizes the importance of a thorough survey of the bog in each case, before commencing operations, in order to determine what maximum depth of excavation will be most favourable to recovery of the peat contained in the area to be worked.

In the shallower portions of the bog, sufficient peat slop to cover the entire drying-area will not be excavated in the width of cut fixed as above stated, and proportionate areas of the drying-field will necessarily be left unspread. This tends, in practice, to increase the area required for operation beyond that theoretically necessary.

Although a wide spreading-area is manifestly of very great advantage the width will naturally be restricted by both mechanical and economic limitations. Both the cost and the mechanical difficulties of operating a conveyer system will be increased as the conveyer is lengthened. The size of the excavator must be also correspondingly increased. A point will be reached where the advantage of the increased width of the spreading-area will be more than offset by the overhead cost of the more expensive machines required. This will depend on the character and design of both excavator and conveyer, and can only be determined by actual experience.

Several automatic peat conveyers which have been developed in Europe, are effective over the following distances:—[1]

Wielandt	45 to 57 yards
A.H.W. (Sweden) (Wielandt system)	30 " 43 "
Strenge, small pattern	38 " 43 "
Siemens Elektrische Betriebe	98 yards
Dolberg	45 "
Baumann-Schenck	26 to 114 yards

Persson's conveyer (Sweden) delivers the peat up to about 220 yards, and Ekelund's to twice that distance from the excavator. These machines, however, are not automatic, the moulded peat blocks being transported on short lengths of board or pallets carried on two moving cables.

The conveyer developed by the Peat Committee, and successfully operated at Alfred, affords a spreading-area 800 feet wide, and it appears probable that this is somewhere near the limit of length for conveying apparatus of the type employed.

In the report of the British Fuel Research Board plans have been outlined for a theoretical production of 120,000 tons of fuel per annum by six machines with a spreading-area of 750 feet in width.[2] A rectangular area of 6,400 yards by 4,250 yards containing 5,625 acres is laid out, as shown in Figure 25[3] so that six machines each with an output of 10 tons per hour, and with a capacity of 20,000 tons each in 100 days of 20 hours, may work for fifty years without the working-area of one plant interfering with that of another.

During the first twenty years excavation would be performed only along the sides of the trenches (a), but after 20 years the ends of the trenches are also used as working-faces (b). The position in the fiftieth year is shown in (c). At the end of that time each machine will have excavated 310 acres, and the spreading-grounds will be in contact. At this stage the No. 1 and No. 4 plants have each developed working-faces of 5,450 yards or a total of 10,900 linear yards. The original working-face developed by each machine being 3,200 yards, there is consequently sufficient working-face to accommodate the No. 1, No. 2, and No. 4 plants on the No. 1 and No. 4 areas, the No. 2 area being left unoccupied. Similarly the No. 3, No. 5, and No. 6 plants can be accommodated on the No. 3 and No. 6 areas. Operation can thus be carried on until the 85th year when the drying-areas reach the edge of the portions of the bog previously cut away by the No. 2 and No. 5 plants (d).

[1] The Production of Air-dried Peat, Report of the British Fuel Research Board for the years 1922, 1923.
[2] Op. cit.
[3] For the sake of clearness of explanation a strictly symmetrical layout is shown, which, naturally, would have to be modified to suit the particular conditions of the bog being worked.

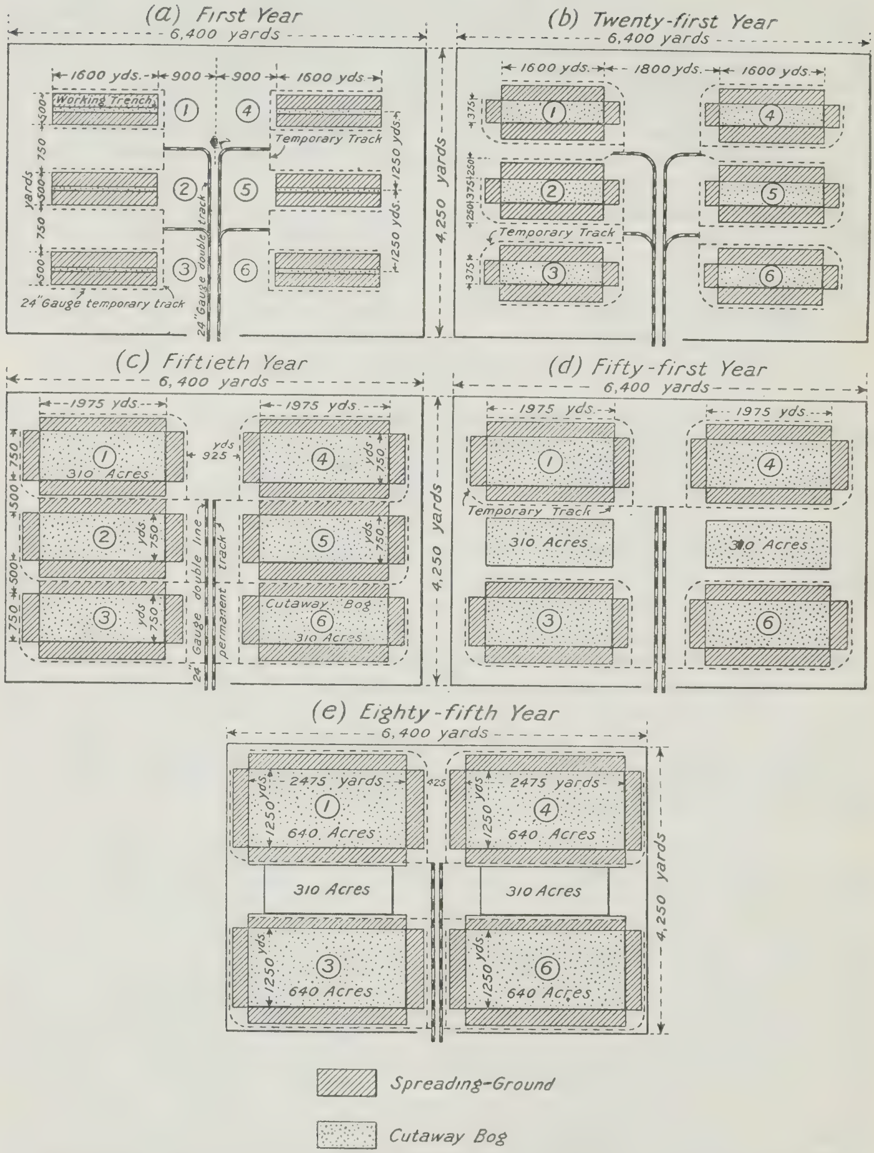


Figure 25. Theoretical layout of drying-ground for a fuel production of 120,000 tons per annum

Surface of Drying-ground

When the bog adjacent to the excavation is utilized as a drying-area, the condition of the surface is of material importance. This will be readily appreciated when the physical properties of a well-humified, undrained bog are understood. A well-humified bog, which has no shrubby growth or moss covering the surface, will have practically the same moisture content from its floor to the surface, and macerated peat with 90 per cent moisture content when spread on such a surface will always assume the moisture content of the entire bog—the evaporation of moisture taking place at the surface of the spread macerated peat—or practically so by the transfer of water from the bog by capillary action. The nature of the vegetation growing on the surface of the bog is, therefore, of great importance, and has material influence on the efficiency of the bog as a drying-surface. The Alfred bog, which is similar to many Canadian peat deposits, is covered with a low shrubby growth consisting for the most part of heath plants, which when pressed down by the spreader makes an ideal drying-surface. After two or more seasons' spreading, the brush dies, and the wet peat is then laid on the upper layer of moss, which covers the surface of the bog to a depth of 12 inches or more. A bog covered with moss provides a favourable surface for drying peat under Canadian climatic conditions, when the bog is properly drained. In Ireland, owing to the more humid climate, footing or standing the peat blocks on end and in clamps of 9 to 12 is almost essential to the proper drying of the peat, but it is found that this procedure does not have to be resorted to in Canada.

When, however, the surface of the bog has been burned over, or has been stripped of its surface moss for some other reason, and well-humified peat is exposed, such areas cannot be employed for drying.

In order to render such surfaces available for drying purposes, experiments were conducted at Alfred in 1921 to ascertain whether seeding with a mixture of grasses would form a suitable growth on the surface to permit the spreading of macerated peat. The period of observation for results was, however, too brief to enable definite conclusions to be reached, but the indications were that, by use of a suitable grass mixture, very considerable improvement of such surfaces can be effected.

Under continuous operation the drying-field rapidly becomes smooth and covered over with small particles of fuel broken from the blocks when harvesting. These small pieces, however, do not readily absorb water, and, therefore, have no material effect on the quality of the drying-surface.

Rate of Drying

The rate of drying of the wet peat spread on the field is dependent on numerous factors, such as method and depth of spreading, degree of maceration of the raw peat, and weather conditions.

Under the method of spreading adopted at Alfred, spaces produced by shrinkage quickly open up along the lines of the cuts made in the peat pulp when spread on the drying-ground, with the result that five sides of each block are exposed to the air. (Plate XLVI.)

The thickness of the blocks is relatively the most important factor to be considered in drying. Peat spread 6 inches thick will require 7 to 10 days longer to become equally dry as peat spread 5 inches thick, under the same weather conditions.

A series of observations made at Ticknevin, county Kildare, Ireland, during the summer of 1919 with regard to the effect of size of the blocks on rate of drying, gave the results shown in the following table.[1]

Dimensions of block	Water ratio 1·5 (60 per cent water) reached in	Water ratio 0·5 (33⅓ per cent water) reached in
2 in. x 2 in. x 5 in.	6 days	10 days
3 in. x 3 in. x 7½ in.	10 "	16 "
4 in. x 4 in. x 10 in.	12 "	30 "
5 in. x 5 in. x 12½ in.	17 "	41 "

From observation covering three seasons of actual operation at Alfred, 1920-22, the conclusion was reached that where macerated peat with 90 per cent moisture content is spread 5 inches thick, 28 days would appear to be the shortest period in which the peat becomes dry enough for shipment as a commercial fuel, and then only under most favourable weather conditions.

Since drying conditions are more favourable during the earlier part of the season, it is practicable to spread the peat as deep as 6 inches up to the end of June, but it may be found advantageous to spread only 4 inches thick after the first week in August to lessen the danger of injury to the fuel by early frosts.

A series of curves accompanying Appendix A illustrates actual rates of drying of peat at Alfred under various conditions and at different times of the year.

Weather Conditions and Length of Season

The production of air-dried peat fuel is not only at all times naturally affected by the weather, but the length of time in each year during which it can be successfully carried on is strictly limited within the period of duration of favourable weather conditions.

The influences exerted on the drying of the raw peat by temperature, humidity, wind velocity, length of day, hours of sunshine, rain, and frost, all have an important bearing in this connexion.

The factors affecting rate of drying in the open air are so extremely variable and complex, that it is impossible to construct any accurate formulae which would serve as a reliable guide in actual operation, and only a few general principles can be laid down.

It must be considered that rapidity of drying is not the chief object to be attained, since too rapid drying may cause serious deterioration in the physical quality of the product.

[1] The Production of Air-dried Peat, Report of the British Fuel Research Board for the years 1922, 1923.

A combination of high temperature with low relative humidity, free ventilation by wind, and a cloudy or partly overcast sky furnish ideal drying conditions for machine-peat fuel.

By the action of wind the more saturated layer of air next to the peat blocks is removed, and fresh volumes of air with greater absorptive capacity are brought in contact with the surface of the peat block. The direct rays of the sun tend to form a hard crust on the outside of the block, which shrinks more rapidly than the moist inner core, producing surface cracks or checks. Later on, with continuous, hot, sunny weather these may open up leading to more or less disintegration of the block, as a result of which its appearance is injured and losses occur in harvesting. Peat dried more slowly under open sheds looks better and is firmer than if dried in the sun. Since, however, the erection of drying-sheds is in no sense economic, the only means of combating this tendency open to the operator is to retard drying by a thicker spreading of the peat slop in the early part of the season when the sun's rays are strongest.

Since relative humidity rises with the lower temperatures prevailing at night, and the drying process is thereby slackened, or under certain conditions may cease altogether, the length of day is a factor of some importance. In this respect the long hours of daylight during the summer in Canada exercise a very favourable influence on the drying of peat.

For the reason already stated, viz., the action of the colloidal skin in waterproofing the surface of the peat block after a few hours' exposure to the air, the effect of rain on the peat spread on the bog is not at all serious. However, when the pulped peat is freshly laid on the ground, the occurrence of heavy rain tends to wash the fine peat substance into the openings between the blocks where it acts as a cement. Not only is the area of the surface exposed to the air reduced, but the blocks must be broken apart when dried, thereby injuring the appearance of the fuel.

The effects of frost are more important. For several months in the year the severe winter conditions prevailing in most parts of Canada preclude any attempt even to excavate the raw peat from the bog. For a longer period it is impossible to dry the excavated peat in the open air. Observations show that the drying conditions are generally most favourable in the early part of the summer, and gradually decrease until in late November very little if any drying takes place.

Handling and Disposal of Fuel

Storage

As already stated handling of the manufactured fuel from the surface of the drying-ground to storage is the most expensive operation in the production of air-dried peat fuel.

Storage piles should preferably be located on firm ground adjacent to the point of shipment in such manner as to permit the employment of mechanical loaders. Under the most favourable circumstances the re-handling of the fuel from storage to railway cars adds considerably to its cost. For this reason it will be found desirable to restrict storage at the bog to a minimum, and as far as possible to harvest directly to railway cars for shipment.

In order to minimize the danger of loss of fuel in storage by fire, the storage area should be of sufficient extent to provide accommodation for a number of piles with divisions between them, which will permit ready insulation and control of any fire which may be started by accident.

Fire in Storage Pile

During the fall of 1921 about 2,500 tons of fuel in storage at Alfred was destroyed by fire. Owing to the character of the equipment installed at that time and available for loading and storage, it had been necessary to store this fuel in one long pile 22 feet deep, 30 to 40 feet wide at the top and over 100 feet wide at the base.

The origin of the fire was not ascertained. During the previous season a quantity of peat dust and screenings had accumulated at the end of the trestle, and the newly manufactured fuel partly covered this pile of fines. The fire apparently originated in these screenings at or near their juncture with the new peat fuel. Some heating had been noticed in the pile of screenings several weeks earlier, and since that time it had been under careful observation. About a month earlier a car had been loaded with fuel from a point close to the spot where the fire first showed, and no rise above normal temperature had then been observed. It is possible that a burning cigarette end, or a spark from a passing locomotive, falling into the screenings was covered by freshly dumped fuel, and ignited the pile at a considerable depth. The rapidity with which the fire developed appeared to indicate that it was of very recent origin. The theory that it was the result of spontaneous combustion has little to support it. Peat has been similarly stored in large quantities for a great many years past in European countries and there is no record of a fire originating in this manner.

Storage in the Open Air

Peat fuel can be stored in the open equally as well as soft coal. Piles stored for two years showed no deterioration a foot from the surface. The quality of the fuel actually tends to improve in storage by the drying-out of any wet blocks contained, and the tendency towards uniformity of distribution of moisture throughout the pile. Gradual slow drying in the storage pile also tends to increase the firmness and density of the fuel blocks.

Production of Fines

The loss from breakage due to handling of the peat from field to storage is hard to determine accurately. It varies with the dryness of the fuel, the distance it is allowed to fall when being dumped on the storage pile, etc.

When peat is harvested with 30 per cent water content the losses are small, and from experience at Alfred should not, on the average, exceed 5 per cent. But when the fuel is allowed to remain on the drying-ground until it has a water content of 25 per cent or less, the breakage in handling is greatly increased and the losses may amount to 15 per cent or even more.

An approximate measure of these losses is afforded by the record of shipments direct from the drying-fields in 1922. These records are, however, imperfect owing to the fact that the screenings were not actually weighed. The procedure in loading was as follows. Small cars loaded with peat from the field were weighed at the loading platform and their fuel contents dumped into the railway cars after screening. The difference between the net weight of the small cars dumped into a railway car and the weight of the fuel in the railway car as determined by the railway weigh scales, was assumed to be the weight of the screenings removed. Between July 25th and August 19th, 28 railway cars were loaded from field No. 1 and the screenings amounted to 15·7 per cent of the total weight of peat harvested. Owing to the destruction of the loading trestle by fire in November 1921, and to the fact that the new loading equipment was not ready for use until July 25th, this peat had remained on the field for several weeks after it was ready to harvest, and was consequently extremely dry and brittle.

From August 29th to October 19th, 74 railway cars were loaded from field No. 3, the average percentage of screenings being 9·5 per cent. This percentage, however, was very considerably in excess of normal, due to the fact that the greater part of field No. 3 was used for the first time during the season. Only the trees and larger brush had been removed and the presence of a large amount of small brush caused considerable breaking up of the fuel in harvesting. Fuel spread on a strip, 50 yards in width, adjacent to the working-face, which had been previously cleared and used as a drying-ground by Plant No. 2 in 1921, had a very much lower average content of screenings.

Assuming the drying-ground to be properly prepared and levelled, and the peat to be harvested when in the most suitable condition for shipment, the screenings may be fairly estimated at 5 per cent of the total fuel harvested. This means that with an output of 20,000 tons of saleable fuel, there would in addition be obtained 1,000 tons or more of screenings.

Disposal of Fines

Peat screenings, unlike slack coal, have a money value in some cases equal to or even greater than that of the fuel itself depending on the market which is available for them as produced. They can be utilized in several ways, of which the principal are as follows:—

(1) As filler for chemical fertilizers.
(2) As a carrier for bacteria in organic fertilizers.
(3) Directly or combined with fertilizing elements as a soil conditioner, especially for lawns and golf links.
(4) In the manufacture of stock foods.
(5) As a packing material for fruits and vegetables.
(6) For sanitary purposes.

(1), (2) The use of peat in the manufacture of fertilizers in the United States has already reached very considerable proportions and is increasing. Peat fertilizer first entered the market in commercial quantities in 1908.

The following table shows the quantities of air-dried peat reported as being utilized for this purpose during the period 1908-1922, and average prices obtained.

TABLE XVI

Air-dried Peat used in Manufacturing Fertilizers in the United States, 1908-1922[1]

Year	Tons (2,000 lbs.)	Average price	Value
		$	$
1908	23,000	5·27	121,210
1909	26,768	4·44	118,891
1910	37,024	3·79	140,209
1911	51,733	4·97	257,204
1912	41,080	4·53	186,022
1913	28,460	5·96	169,600
1914	37,729	6·62	249,899
1915	38,304	6·75	258,447
1916	48,106	7·00	336,004
1917	92,263	7·14	658,500
1918	79,573	9·74	775,313
1919	54,690	10·19	557,240
1920	63,272	12·23	773,635
1921	29,460	8·52	251,046
1922	57,747	6·39	369,165

It should be noted that prices of peat sold for the manufacture of fertilizers are largely governed by the nitrogen content of the peat, and that the higher the percentage of nitrogen the higher the price obtainable.

Air-dried peat sold for the manufacture of fertilizers is usually further dried artificially, to reduce the moisture content to about 10 per cent, and if air-dried peat fuel with 30 per cent moisture content is saleable at $5.00 per ton, screenings artificially dried to 10 per cent moisture content, would require to be sold at $6.43 per ton to produce the same return, without taking into account the cost of grinding and artificial drying.

Several carloads of peat screenings were sold to fertilizer companies during the operations of the Committee at Alfred, and contracts for the entire production would have been readily obtainable had it not been for the unsatisfactory state of the fertilizer market. There is reason to believe, however, that a market can be found in Canada for several thousand tons annually as soon as regular production is established.

(3) Peat screenings ground into dust, either with or without the addition of other fertilizing materials, have been found valuable as a soil conditioner for lawns, and are of special value for golf putting-greens.

(4) Peat has to some extent been used in the United States in compounding stock foods. Screenings to be available for this purpose would, however, require further heat treatment.

[1] Peat in 1917, by C. C. Osbon, U.S. Geological Survey II, 20.
Jour. American Peat Society XIII-2, XIV-1, XIV-4, XV-3, XVI-3.

The consumption of air-dried peat in the manufacture of stock foods since 1912 is reported to have been as follows:—

TABLE XVII

Peat used in Compounding Stock Food in the United States 1912-1922[1]

Year	Tons (2,000 lbs.)	Average price per ton	Value
		$	$
1912	3,000	6·00	18,000
1913	4,800	5·75	27,600
1914	a	....	a
1915	3,980	7·56	30,090
1916	4,300	7·50	32,250
1917	5,100	10·08	51,400
1918	7,096	15·07	106,935
1919	6,402	15·45	98,940
1920	b 9,182	15·58	b 143,047
1921	b 946	9·59	b 9,073
1922	b 1,893	11·02	b 20,864

a Not available.
b Includes small quantity of moss and stable litter.

(5) Peat mull (dust) has been successfully used for many years in Europe for the wintering or preservation of fruits and vegetables, and for packing eggs, meat, fish, and other perishable articles.[2] Experiments conducted by Erik Nystrom in Sweden in the preservation of apples have shown that peat dust is an excellent packing material for fruits.[3]

(6) Owing to its high absorptive and deodorant qualities peat dust is of great service for use in earth closets. Several years ago residents at a summer resort near Ottawa, purchased a considerable quantity for this purpose, and its use was found highly satisfactory. In communities not provided with facilities for disposing of sewage by the use of water, it is probable that sale could be found for small quantities of peat for such sanitary use.

In steam-power installations, equipped for burning sawdust, peat screenings have been used to advantage as a fuel for steam generation.

CHARACTERISTICS OF AIR-DRIED MACHINE-PEAT FUEL

Standard peat fuel as manufactured at Alfred is made in blocks which are roughly rectangular in shape and about 2 by 2½ by 8 inches in size. The blocks are black to brownish in colour, have a specific gravity of about 0·9, and when piled occupy about 1¾ times as much space as an equal weight of anthracite. With a 30 per cent water content the fuel is hard and tough, requiring a sharp blow with a hammer to break it.

[1] Peat in 1917, by C. C. Osbon, U.S. Geological Survey II 20.
Jour. American Peat Society XIII-2, XIV-1, XIV-4, XV-3, XVI-3.
[2] Handbook on the Winning and the Utilization of Peat, by A. Hausding.
[3] Journal Canadian Peat Society, Vol. II, No. 3.

It ignites easily, burns at first with a long flame giving off a small amount of very light smoke for a short time. As the volatile matter is consumed the flame is reduced in length, and the remaining carbon burns with a steady, intense glow until combustion is complete, holding fire and giving off a mild heat for a long time. A peat fire requires feeding at shorter intervals than coal and in comparatively small quantities at a time. This is necessary because 60 per cent of the fuel is composed of volatile matter, and rapidly generates large volumes of gas, which either escape up the chimney unburned, or produces an intensely hot fire.

The following are the principal defects of air-dried machine-peat fuel: it is more bulky and difficult to handle than coal, burns more rapidly and is of lower heating-value. It has, however, the advantages of being easily ignited and of burning freely until entirely consumed, leaving a small residue of fine ash without clinkers. Moreover, a peat fire is very easily controlled, and where peat is used in conjunction with coal it assists in promoting more even regulation of the fire and more complete combustion of the coal.

MARKETING PROBLEMS

Owing to the incidental character of the manufacture and sale of peat fuel at Alfred, during the investigations carried on by the Committee, the marketing of the product was affected by several handicaps, which would be less serious or in some cases would disappear under conditions of regular commercial production.

Sale through the ordinary commercial channels, viz., by established coal and wood dealers, was as a general rule impracticable for several reasons. Peat was to most customers a new and untried fuel. No guarantee could be given either as to the amount of fuel available, or as to continuance of the supply for another year, which would induce any individual dealer to go to any expense in establishing a trade. The fuel was more bulky than coal and the ordinary coal carts generally used required alteration for its economic handling. Carters and labourers employed in delivering coal found it more troublesome to handle than coal and, therefore, were not favourably disposed towards it. Additional storage facilities were required, the cost of which was not justified where the supply was small, and its continuance uncertain. Dealers in Ottawa and Montreal were willing to contract for the purchase of all the peat fuel produced if given exclusive rights of sale. This could not be done without arousing antagonism of other fuel dealers, and it was the policy of the Committee, in accordance with the objectives of the investigation, to distribute the fuel in small quantities for purpose of trial to as large a number of customers as possible.

Under the conditions of shipment, difficulty was also experienced at times in obtaining open, railway cars when wanted. Delays in shipment, on this account, in many instances led to unavoidable disappointment of customers and in some cases to cancellation of orders.

Sales at Ottawa, to which point a large proportion of the fuel was shipped, were made by a special selling-agent not in the fuel business. Considerable quantities were sold at the bog and in Montreal and Peterborough, where there was a ready demand for much larger quantities than could be supplied.

Shipments of one or more carloads were also made to the following places:—

In Ontario: Alexandria, Almonte, Arnprior, Belleville, Bourget, Braeside, Brockville, Carleton Place, Casselman, Cornwall, Cumberland, Curran, Finch, Hawkesbury, Iroquois, Kingston, Kitchener, Maxville, Merrickville, Morewood, Navan, New Liskeard, Pembroke, Pendleton, Plantagenet, Prescott, Renfrew, Richmond, Russell, Sarsfield, Spencerville, Vankleek Hill, and Toronto.

In Quebec: Aylmer, Hull, Joliette, La Tuque, Philipsburg, Pont Rouge, St. Anne de Bellevue, St. Eugene, Shawville, and Three Rivers.

The immediate market for peat fuel is for domestic consumption, and this will continue to be practically the only market until the fuel is manufactured in large quantities and a reserve built up so that any industry making use of it may be assured of a constant supply.

Only a few cars of fuel were shipped from Alfred for other than domestic use. A carload was used to dry sand for manufacturing a special white plaster, and was found highly satisfactory, owing to its freedom from soot. Several carloads were used for drying moulds in a steel foundry. Two companies used it with success for burning lime, and a quantity was purchased for steam purposes. Several carloads of screenings and frozen peat were shipped to Chatham for use in manufacture of fertilizers.

There was a strong demand for peat fuel for domestic consumption, particularly in 1922, when practically the whole output available for sale was disposed of before the middle of the manufacturing season, and numerous orders had to be refused or cancelled.

Nearly 200 replies received from consumers and dealers in response to a questionnaire issued during the following winter indicated very general satisfaction from the use of peat fuel. Dealers were of the opinion that much larger quantities could be handled another season.

Freight Rates

The most important factor in limiting the radius of practicable shipment was the burden of added cost imposed by freight rates.

Special rates of $1.40 and $1.50 per ton from Alfred to Ottawa (41 miles) and Montreal (70 miles), respectively, were charged by the railway company on shipments in carload lots with a minimum weight of 40,000 pounds per carload.

Rates for shipments to all other points were under a tariff rate on a mileage basis as follows:—

Distance	Freight rate per ton
Up to 10 miles	$ 1.10
Over 10 to 20 miles	1.20
" 20 to 30 "	1.40
" 30 to 50 "	1.70
" 50 to 75 "	1.80
" 75 to 100 "	2.10
" 100 to 125 "	2.30
" 125 to 150 "	2.80
" 150 to 175 "	3.10
" 175 to 200 "	3.30

(with additional charges for greater distances)

High as these rates are in proportion to the value of the commodity, ($5.00 per ton f.o.b. at point of shipment) the transportation charges were greatly increased when shipments were consigned to points on railways other than those on which the traffic originated. In this case, where transfer of cars was made at points other than Ottawa and Montreal, the local mileage rates on each railway over which the shipment was carried had to be paid.

In the absence of any definite plans for continued commercial production, the Committee was not in a favourable position to approach the railway companies for the purpose of asking any modification of these rates. When any substantial regular freight from this source can be assured, it is probable that the matter of granting more favourable rates will be sympathetically considered by the railway officials. In the event that through mileage rates, where shipments are carried on more than one railway, cannot be obtained, it is suggested that a special, low commodity rate similar to that for hauling cordwood, might be granted.

Delivery Charges

As already pointed out, peat fuel is more bulky and somewhat more difficult to handle than coal, and requires more space for storage, and carts of greater capacity than those ordinarily used for delivery of coal. The cost of delivering from the railway car to the consumer's fuel bin consequently is higher than that for coal. Cost for local delivery of peat varied from 75 cents per ton in the smaller towns where delivery was made direct from the car, to as high as $3.00 per ton, where the dealer had to unload into storage, and reload into carts as required. The average cost is estimated to have been between $1.50 and $2.00 per ton.

POWER

When attempts are made to manufacture peat fuel on a large scale the question of power for the operation of the plant becomes of considerable importance. With the small unit plants, hitherto employed, it has been common practice to supply the power through the medium of a steam engine and a steam generator specially designed for the burning of peat. Such power equipment is usually mounted on the same platform as the peat machine or on an independent platform supported on rails or on caterpillars which permit it to be moved over the surface of the bog along with the peat machine. A power plant of this type must necessarily be of low efficiency, since the conditions of its operation are such as to prohibit the employment of a high type of prime mover, with its attendant condenser and other auxiliaries. The ratio of fuel consumption to mechanical power produced will, therefore, be excessive.

Moreover, the problem of supplying peat fuel to a moving plant is a serious one. Labourers must be specially employed to collect the fuel from the field as required from day to day. Special tracks must also be laid, to keep up to the peat machine as it progresses along the working-trench.

Not only are the fuel requirements of such a plant inordinately high compared with the power obtained, but it may be seriously questioned whether such use of a portion of the peat fuel manufactured is economic. If the peat consumed in operating the plant is charged against operation at cost of production, the profit per ton on all fuel thus used is lost. Since the labour and other costs of delivering peat fuel to the boiler platform of a moving peat-machine are as high as the cost of loading the same fuel on cars for shipment, and in some cases may be even higher, the price at which the fuel can be sold f.o.b. cars fairly represents its cost to the plant. This in the case of the operations at Alfred was $5.00 per ton. At such a price peat fuel, fired under the very inefficient type of steam generator which must be employed, is too expensive as a source of power, and can be much more advantageously utilized for other purposes.

Finally, since electric energy can be more efficiently transmitted to the various plant units requiring power, than can power developed at the shaft of the engine through belts or gearing, plants designed for large-scale production will be most effective, when equipped with directly connected electric motors and supplied with electric energy from some common source.

Four sources of supply of electric energy may be considered:—

(1) From a stationary power plant equipped with peat-fired, steam boiler, and steam engines and electric generators.

(2) From a peat gas-producer plant with gas engines and electric generators.

(3) By the use of hydro-electric power where available.

(4) By the employment of internal combustion engines of the Diesel type using crude oil as a fuel to run electric generators.

(1) When energy is to be supplied to several units operating on the same bog, a permanent steam-power plant could be installed which would have a very much higher overall efficiency than that possible with the smaller portable plants usually employed. The peat fuel required for the boilers, also, could be much more economically delivered to such a plant, than to one which is continually moving. A season's supply of peat fuel could be delivered and stored at the plant during the course of the regular harvesting operations.

(2) The peat gas producer could be used to advantage only where there was a market available for surplus electric power above the requirements for operating peat machines, and for the by-products when these are recovered.

(3) Hydro-electric power is available at a number of the bogs surveyed by the Department of Mines, and the use of such power would substantially reduce the capital expenditure necessary for the establishment of a peat-fuel manufacturing plant.

Taking into consideration the reduced overhead charges due to the elimination of interest on the investment of a power plant and the depreciation on same, it has been estimated that where hydro-electric power is available at $35.00 or less per h.p. for 24 hours' service, it could be employed to advantage.

(4) From any of the first three sources high tension, transmission lines must be erected around three sides of the drying-ground and at a sufficient distance to allow for the widening of the working-trench and consequent extension of the drying-area during an entire season's operations. Before beginning operations each succeeding year these transmission lines would have to be moved a similar distance.

In case, however, Diesel engines are employed as a source of electric energy, these high tension transmission lines would not be required. Inasmuch as the weight of a Diesel power-unit does not exceed that of the excavators already used, it can be installed on a platform carried on caterpillars and kept a short distance ahead of the excavator. Electrical energy could, therefore, be directly supplied through short flexible leads to the excavator platform from which connexions to the conveying and spreading-apparatus could be easily made.

The following estimate of cost of power supply from a portable Diesel engine unit as compared with that from a stationary steam plant with boilers fired with peat fuel, shows that the former can be utilized to good advantage. A plant with an average production capacity of 10 tons of saleable fuel per hour, will require approximately 140 to 150 h.p. for operation of the various machines, and to ensure the constant supply of this amount of power, estimates are based on a prime mover capacity of 200 h.p.

Estimated cost of 200 h.p. for 10 hours

Steam-power plant		*Diesel unit*	
Peat, 10 tons at $5.00	$ 50 00	Oil, 100 gallons at 12c	$ 12 00
Engineer	8 00	Operator	8 00
Fireman	3 50	Oil and supplies	1 00
Assistant	3 00	Repairs	5 00
Oil and supplies	1 00		
Repairs	5 50		
Total	$ 71 00		$ 26 00

LABOUR COST OF PRODUCTION

The primary objective of the investigation was the development of machines which would eliminate manual labour to the greatest possible extent, and thereby reduce the labour costs of manufacture. The extent to which this was accomplished may be seen from the following table showing comparative labour costs of manufacture of peat fuel spread on the drying-ground by (1) the small Anrep plant operated by the Mines Branch at Alfred in 1910-11; (2, 3, and 4) the machines operated by the Committee; and (5) the estimated cost by a perfected plant, embodying all improvements indicated as a result of the research and experimental work of the Committee.

TABLE XVIII

Comparative Labour Costs of Operation with Different Plants

Plant	Men required	Daily output (10 hr.) tons	Daily wages	Labour cost per ton on drying-ground
Anrep plant 1910-11	13 and 4 boys	30	$ 49.00*	$ 1.63
Anrep Plant No. 1, 1919-20 (with mechanical excavator)	14	60	52.00	0.86
Moore Plant No. 2, 1919-21	7	60	30.50	0.51
Combined Anrep-Moore Plant No. 4, with steam power 1922	8	80	33.50	0.42
Anrep-Moore Plant No. 4, re-designed to be operated by electric power	7	100	31.00	0.31

* In making the above comparison, the wages for operation of the small Anrep plant used in 1910-11, have been calculated according to the scale of wages paid in 1919-22. The actual daily wage for this plant in 1910-11 with the wage-scale then prevailing was about $26.50.

From the table it will be seen that the labour cost of laying down peat fuel on the drying-field has been reduced in actual operation to about one-fourth of that of the small Anrep plant, which was operated by the Mines Branch at Alfred in 1910-11; and that a further reduction to less than one-fifth that of the small Anrep plant may be anticipated by the employment of a new machine according to the designs recommended.

Though Plant No. 1 could excavate sufficient peat to produce 10 tons of fuel or more per hour, the limitations and defects of the spreading system reduced the working capacity of the entire plant to approximately 60 tons per 10-hour day.

Plant No. 2 was designed to give an output of 60 tons of fuel per 10-hour day, and proved capable of producing that amount when in regular operation. Although its capacity and cost of operation were satisfactory, it was discarded for reasons set forth elsewhere in this report.

It was anticipated that Plant No. 4 would have a production capacity of 100 tons per 10-hour day, but this could not be realized in operation chiefly on account of two defects. The steam boiler plant, which was improvised by combining the two steam boilers already in use on the bog, was wasteful in the use of fuel and, owing to excessive heat losses, the supply of power was inadequate. The pulping machine installed proved to be too small. This could not be foreseen since machines of the kind employed had not been previously used in manufacturing peat fuel, and the capacity of the machine installed could only be estimated from performance of similar machines in handling such a material as kelp.

The combination Anrep-Moore plant, recommended by the Committee, has been designed throughout to have a maximum capacity of over 15 tons per hour of actual operation or upwards of 125 tons per 10-hour day, and, when electrically operated with adequate power supply, an average output of 100 tons per 10-hour day should be easily maintained.

With an hourly output of 10 tons of peat fuel, and with the wage scale prevailing at Alfred in 1922, the labour costs of actual manufacturing operations may be divided as follows:—

1—Power plant attendance	$0·08 per ton
2—Excavating	0·08 "
3—Conveying and spreading	0·15 "
4—Turning and cubing	0·20 "
5—Harvesting	0·665 "
Total	$1·175 "

The labour cost per ton of the peat fuel laid on the field, covering only items 1, 2 and 3, by a small Anrep plant of the type operated by the Mines Branch in 1910-11, calculated on the basis of the 1922 scale of wages paid at Alfred, would be $1.63 per ton.

With a plant such as recommended by the Committee the cost would be reduced to 31 cents per ton, as follows: 8 cents per ton for operation of a Diesel engine unit to supply the necessary power, 8 cents per ton for excavating, and 15 cents for conveying and spreading.

According to estimates based on actual performance of the machines operated at Alfred, the total cost of production of peat fuel with the recommended plant, working 20 hours per day for 100 days, will be about $3.47 per ton. Since the labour cost of laying down the fuel on the drying-ground is less than 10 per cent and, including the operation of turning the partly dried blocks, the labour cost of manufacture is under 15 per cent of the entire cost of production, it is probable that the practical limit of reduction of labour costs by employment of machines for the manufacturing operations involved, has been nearly reached.

COST OF TURNING AND HARVESTING THE FUEL

By far the most expensive operations involved in the manufacture of air-dried machine-peat fuel are those of turning the partly dried blocks and collecting them from the drying-area.

No machinery has yet been devised that will turn the partly dried blocks on the field, and this must still be accomplished entirely by hand-labour.

It has been found advantageous to have the turning done by piecework, the workmen being paid a fixed rate per 100 feet of row, and the cost under the scale of wages prevailing during the operations carried on by the Committee at Alfred, was found to average 20 cents per ton of fuel produced.

Over one-half of the entire labour cost of producing peat fuel is incurred in collecting the finished product, loading it into small cars and transporting it to the point of storage or shipment. Although the cost of this part of the operations was very substantially reduced by the harvesting device employed at Alfred, the peat must still be picked up from the surface of the drying-ground with forks and this requires a number of labourers.

Any further substantial reduction in labour costs of production, therefore, can apparently be obtained only by improvement of the methods adopted for turning and collecting the manufactured fuel from the drying-ground.

OVERHEAD CHARGES

The total production cost of air-dried peat fuel is estimated to be \$3.47 per ton. This estimate is based on the assumption that a plant of the type recommended with an average production of 10 tons per hour—conditions in other respects being similar to those met with in actual operation at Alfred—be installed. The several items of expenditure included in this figure of cost may be seen and their comparative importance more readily understood by reference to the accompanying chart (Figure 26)

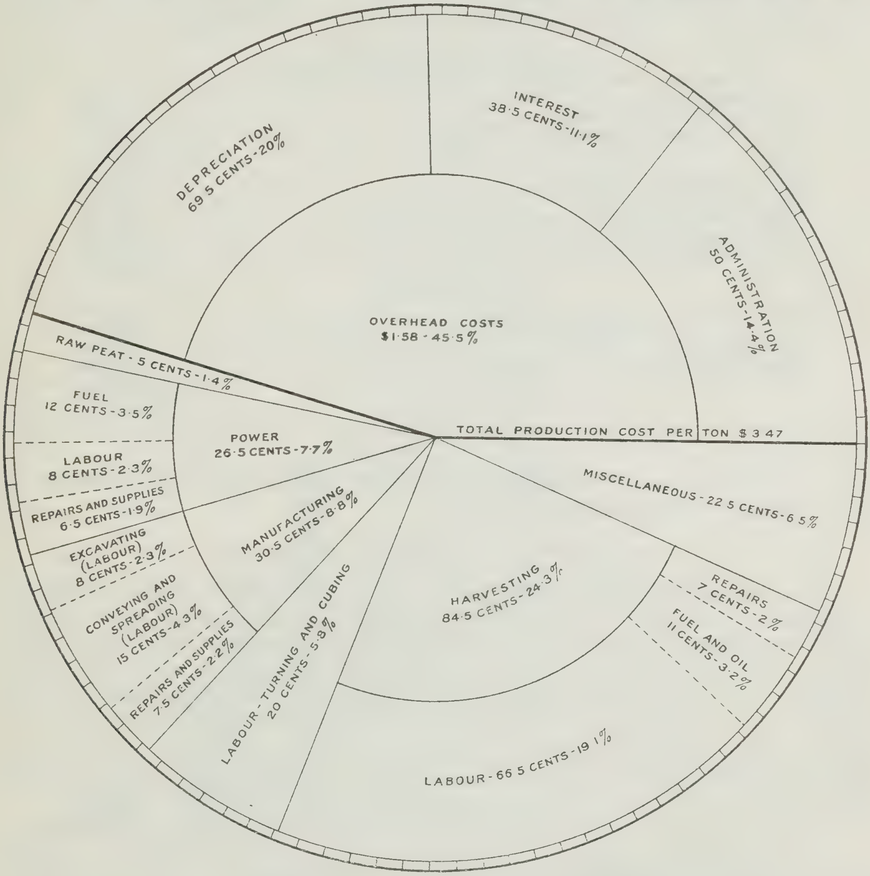


FIGURE 26. Chart showing distribution of costs of production of peat fuel

which indicates that the collection and handling of the manufactured fuel is responsible for approximately one-quarter of the entire cost of production, while depreciation and interest are estimated to amount to over 30 per cent, and administration to approximately 15 per cent of the entire cost.

If further substantial reductions in the cost of producing air-dried peat fuel are to be effected it is evident that these must come from:—

(1) Reduction of cost of machines employed, with consequent lowering of the capital investment necessary.
(2) Lower administration cost.
(3) Introduction of cheaper and more efficient methods of collecting and handling the manufactured fuel.

Overhead charges as computed amount to approximately 45 per cent of the total cost of production. These are based on the following estimate of the capital investment required to install a plant of the type under consideration and which will produce 20,000 tons of saleable fuel per annum.

CAPITAL INVESTMENT

Cost of bog 400 acres at $10.00 per acre (sufficient area for 20 years' operation)	$ 4,000 00
Drainage at $10.00 per acre	4,000 00
Cost of clearing and preparing drying-ground	a 9,000 00
	$ 17,000 00
Diesel engine and equipment	27,500 00
Peat plant (excavator and spreading system)	35,200 00
Harvesting equipment (including railway siding)	24,500 00
Office, shop and tools	2,500 00
Freight installation and sundries	3,300 00
	$ 110,000 00

OVERHEAD

Depreciation {Investment in bog 5 %	850 00
Depreciation {All other capital investment, average 14%	13,020 00
Interest at 7%	7,700 00
Administration, 10% of total turnover	10,000 00
	$ 31,570 00

a This may be regarded as a maximum figure and the cost should not in most cases exceed $5.00 per acre.

The cost based on an annual production of 20,000 tons is equivalent to $1.58 per ton of fuel manufactured.

PLANT No. 3—FINAL DESIGN

At the end of 1922, Plant No. 3 was again completely re-designed as shown in Plate LV. As will be seen the general principles of design of the combined Anrep-Moore plant (No. 4) have been closely followed. A similar framework, supported on two caterpillars and steering rollers, is employed on which the excavating element moves backwards and forwards. A trough and screw conveyer discharge the excavated material into a hopper on the spreading-conveyer. Pulping of the peat is accomplished by means of a small swing hammer mill, supported on the inner end of the conveyer and discharging directly on the belt.

The conveyer-frame is a single span, 85 feet long, supported at either end by caterpillar elements. The spreader resembles the one last tried out on the experimental No. 3 machine, but altered to make its action more positive and the control more complete. The plant is run by two gasoline engines, one 7 to 10 h.p. driving the excavator, and another 15 to 20 h.p. driving the belt conveyer and macerator.

In operation it is expected that one man will attend the excavator, another man will have charge of the spreader, a third man will clean off moss ahead of the excavator and remove obstructions from the drying-field, and possibly a fourth man, or boy, will be required to assist generally.

The machine cuts a section 5 feet wide by 5 feet in depth and will travel from 9 to 10 feet in excavating raw peat sufficient to produce one ton of saleable fuel. With a daily output of 20 tons this will mean a distance of 180 to 200 feet per day so that the total distance travelled before the

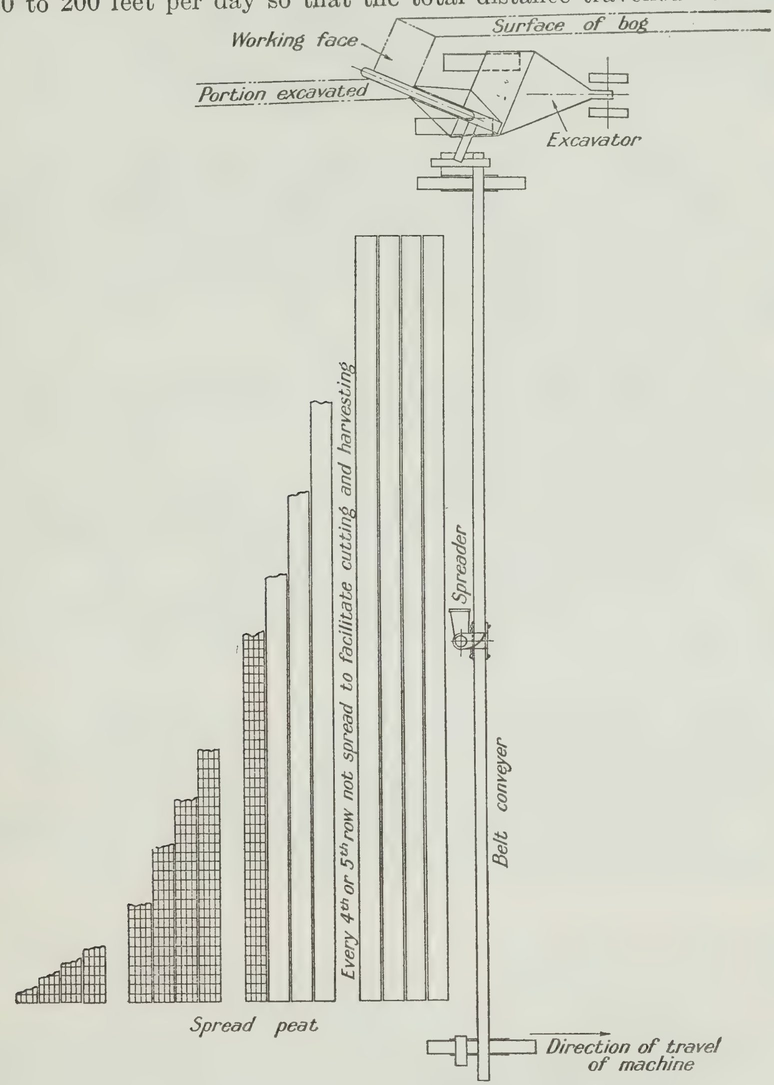


FIGURE 27. General plan of operation of Plant No. 3

drying-field can be used a second time, will be between 7,200 feet and 8,000 feet. Estimating the average drying-period to be 40 days this necessitates a working-face between 3,600 and 4,000 feet long. If this length of face is not available, it will be possible, with such a small plant, to arrange for two or more working-trenches without much loss of material.

Figure 27 shows the general plan of operation. It is estimated that a new machine built according to the final design, and of dimensions similar to those of the experimental plant (No. 3), would have an average productive capacity of 20 tons per 10-hour day. As high as four tons per hour were excavated for short periods with Plant No. 3 when running at maximum capacity. Taking into account all causes of delay, and allowing a reasonable factor of safety, an average production of at least half this amount should easily be maintained for the period of operation.

The peat laid down will have to be turned as in the case of the large machines, but it is probable that harvesting can best be done with broad-tired, dump carts using horses provided with bog shoes, to haul them. Local conditions will so influence harvesting, storage, and loading of the fuel, that no specific plan of operation will be discussed, but if storage can be arranged for within a mile of the drying-field, three men, two boys as drivers, two horses and three or four carts, should be able to handle up to 20 tons daily.

When using a small plant of this kind it may prove more economical to store the fuel in stacks adjacent to the drying-field, and to draw it off to local customers or for shipment, after the frost has hardened the surface of the bog and made transportation easier.

There are certain difficulties in operating a small plant such as No. 3, not encountered with the larger machines. When using the large machines which excavate to a depth of 7 to 9 feet or more, 12 inches or more of moss and fibrous surface peat are mixed with at least 6 or 7 times their volume of well-humified peat, but with the smaller machine which excavates to a depth of 5 feet, the same amount of inferior material is mixed with only 3 or 4 times its volume, so that, in order to produce the same quality of fuel with the small machine, it is necessary to strip off the top surface before excavating takes place.

Another difficulty arises from the fact that the smaller excavator and macerator are more affected by roots, and delays from this cause will be greater proportionately than with the larger machine. The small spreader will require a better prepared drying-field since it is too light to level its own field and owing to the small output, harvesting will have to be performed with a minimum of mechanical equipment and will, therefore, be more expensive.

PLANT No. 4. RE-DESIGNED

As a result of the experience of the Peat Committee in constructing and operating peat machines of two distinct types, and a combination plant embodying the more valuable features peculiar to these, final designs and plans were prepared for a new combination plant, the construction of which was recommended by the Committee. The only portions of the improvised combination Plant No. 4 built and operated by the Committee which were entirely new were the portable belt conveyer and the macerator.

The belt conveyer was designed and constructed with great care, and operated to the entire satisfaction of the Committee. The macerator was entirely experimental having been designed for shredding and pulping material dissimilar to peat. Although a high degree of maceration was obtained and the machine operated with entire satisfaction, its capacity was found to be below that which was required to produce 10 tons of saleable peat fuel per hour. Since, however, various sizes of the macerator can be obtained from stock, this portion of the plant involved no uncertainties regarding its ability to carry out efficiently and properly the operation of pulping the raw peat.

The other portions of the plant possessed inherent weaknesses due to the improper design of certain important elements which the Committee did not feel justified in reconstructing, since the replacement of these elements would have involved considerable expenditure of both time and money and was not deemed necessary in order to make a demonstration of the combination plant which would fully show its possibilities and at the same time serve as a guide for the construction of machines for commercial use.

The platform used in Plant No. 4 was the original platform of the Anrep plant (No. 1) with such alterations as were required to adapt it for use in the combination plant. Owing to the employment of steam power for operation of the various machines, the platform was designed to carry the power plant and auxiliary machinery, as well as the excavating element and macerator, and the necessary housing. It was, therefore, much larger and heavier than would be required in a plant properly designed for commercial operation using electric power as a motive force. Various features of the design, moreover, which were unavoidable on account of the excessive weight of machinery were unsatisfactory, and occasioned difficulties in operation. The caterpillar elements on which the machine was carried were especially designed by the engineer for the Committee at the outset of the investigation, and although constructed in accordance with the best current practice at that time, proved to have a number of defects which caused trouble and loss of time. The excavating element of Plant No. 1 was used in the construction of the combination plant. With the original excavator, it was necessary to elevate the peat three times; first, by the excavator buckets from the bog to a conveyer-trough; second, by an inclined conveyer from this trough to the macerator; and, third, by a similar conveyer to the hopper of the belt conveyer.

In the re-designed plant, the platform carries only the excavating element, the macerator being placed on the inner end of the belt conveyer. By this arrangement not only is the platform freed from the heavy weight of the power plant and auxiliary machinery, as well as the macerator, but the housing required is reduced to a minimum. The dimensions and weight of the platform can therefore be greatly reduced, and its general form and construction adapted solely to the purpose of carrying the excavator. Steering of the machine also becomes a much simpler problem. In the new machine steering is effected by rollers suitably placed near the front end of the platform, and a re-arrangement of the caterpillar elements is made which also facilitates steering and movement of the plant.

The repeated elevation of the raw peat in its path from the bog to the conveyer belt and its transportation through such an extensive and complicated conveyer system was recognized to be faulty, but could not be avoided in Plant No. 4. In the new design this has been greatly simplified. By increasing the length of the excavating element, the two inclined conveyers are eliminated, and the raw peat, raised from the bog by the excavator buckets, is delivered to the macerator and thence onto the conveyer belt without further elevation.

The frontispiece of this report shows in perspective the completed machine, as it will appear when constructed and placed on a bog in position ready for operation.

Excavator

In order to increase the capacity of the excavator as previously employed, it was necessary to increase its speed of cutting. It is not good practice to operate a bucket excavator at too high a speed and this defect has been eliminated in the new design. The new excavator (Figure 28), has been entirely re-designed and has incorporated in it all of the improvements that experience has demonstrated can be employed to advantage. Although its design adheres closely to that of the former one, it provides for a longer excavator arm and for larger buckets. Certain minor changes have been also made in the method of fastening the chain together and guiding the buckets. The difficulty previously experienced of feeding the peat evenly to the macerator, has been eliminated by increasing the capacity of the buckets and by improving the controlling mechanism. Peat slop is delivered directly from the excavator into the hopper of the macerator by a cross-conveyer. The longer excavator arm permits the cross-conveyer to be elevated sufficiently to accomplish this and thus eliminates the two former conveyers which were the source of considerable trouble.

Excavator Platform

The platform of the excavator (Figure 28) is constructed of four main girders, three of which form a triangle. The fourth, a Warren girder, forms a stiffening member and provides also a guide for the rear wheels of the excavator carriage. The two main supporting caterpillars are placed directly under the fourth member—the Warren girder. The method employed for attaching the caterpillars to the platform and the design of the mechanism for driving them has been altered so that the caterpillars can, with freedom, adjust themselves to the surface of the bog. Special care has also been taken to provide a design that will make all of the working parts readily accessible, thus eliminating another of the serious causes of delay in the old machine. The third point of support of the platform is under the apex of the triangle, considering the rear side as the base. This support consists of two large rollers on one shaft, so arranged that they can be turned in any direction even while the machine is at rest. The steering

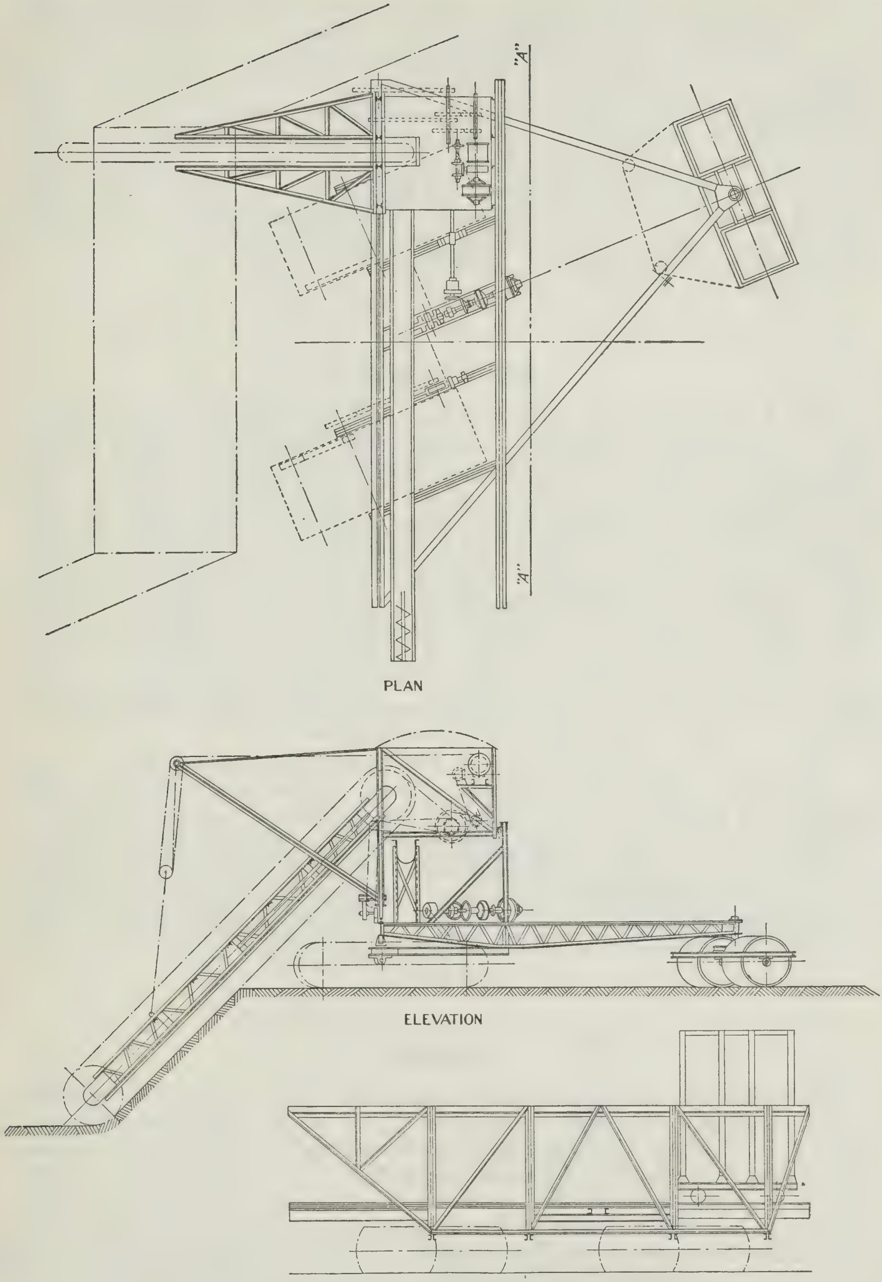


FIGURE 28. Plant No. 4, re-designed excavator platform

of the machine is performed by turning these rollers. The total weight of the excavator is so distributed that the rollers bear no greater load per square inch of bearing-surface than the caterpillars. The frame of the excavator will be entirely open, housing being provided only for the excavating element, transmission machinery, and for the motor used for operating the long conveyer and moving the machine ahead. A 20 h.p. motor is provided for operating the excavator and a 15 h.p. motor for operating the conveyer and moving the machine. All gearing is of standard construction and will be enclosed in cast iron cases. With the exception of the cutting hoops of the excavator, the entire machine can be constructed of standard equipment which is stocked by manufacturers.

Belt Conveyer

The alterations to the belt conveyer in order to permit the installation of the new excavator as described, are shown in Figure 29. These changes affect the ends of the conveyer only and consist in moving the driving pulley to the outside caterpillar and installing an electric motor to drive it, re-designing the inside caterpillar to carry the tail pulley and at the same time providing support for a 36 by 24-inch, type "B", Jeffrey swing hammer mill pulverizer direct connected to a 1,200 r.p.m. 100 h.p. squirrel-cage motor. The motor will also drive the cable drum which moves the portable belt conveyer ahead. To facilitate the moving of the inside caterpillar of the belt conveyer around the end of the excavation, the design provides for a second small caterpillar which will be connected to it by a suitable frame. This will permit the caterpillar element to be moved under its own power when disconnected from the bridgework.

A hopper containing sections of a right and left hand spiral conveyer is provided for feeding the excavated peat to the conveyer belt. The hopper rests directly on the hopper of the pulverizer and the sections of the spiral conveyer and the feeding mechanism under the pulverizer are driven by the tail pulley of the belt conveyer, so that when it is necessary to stop the belt the feeding mechanism will also be immediately stopped. This arrangement will also prevent slopping over of the excavated peat. A housing is provided for the pulverizer and its motor.

Spreader

The spreader will be operated by an electric motor instead of a gasoline engine which has been used heretofore. To supply electric energy to the motor, three trolley wires suitably protected will be stretched along one side of the bridgework. Brushes supported by the unloading carriage will conduct the current from these wires through flexible leads to the spreader. The design provides for the installation of two 20 h.p. motors, one to drive the spreader and the other to drive the conveyer belt. All motors will be equipped with automatic overload cut-outs. The method of operation of this plant will be similar to that of the original combination plant, but a smaller staff will be required.

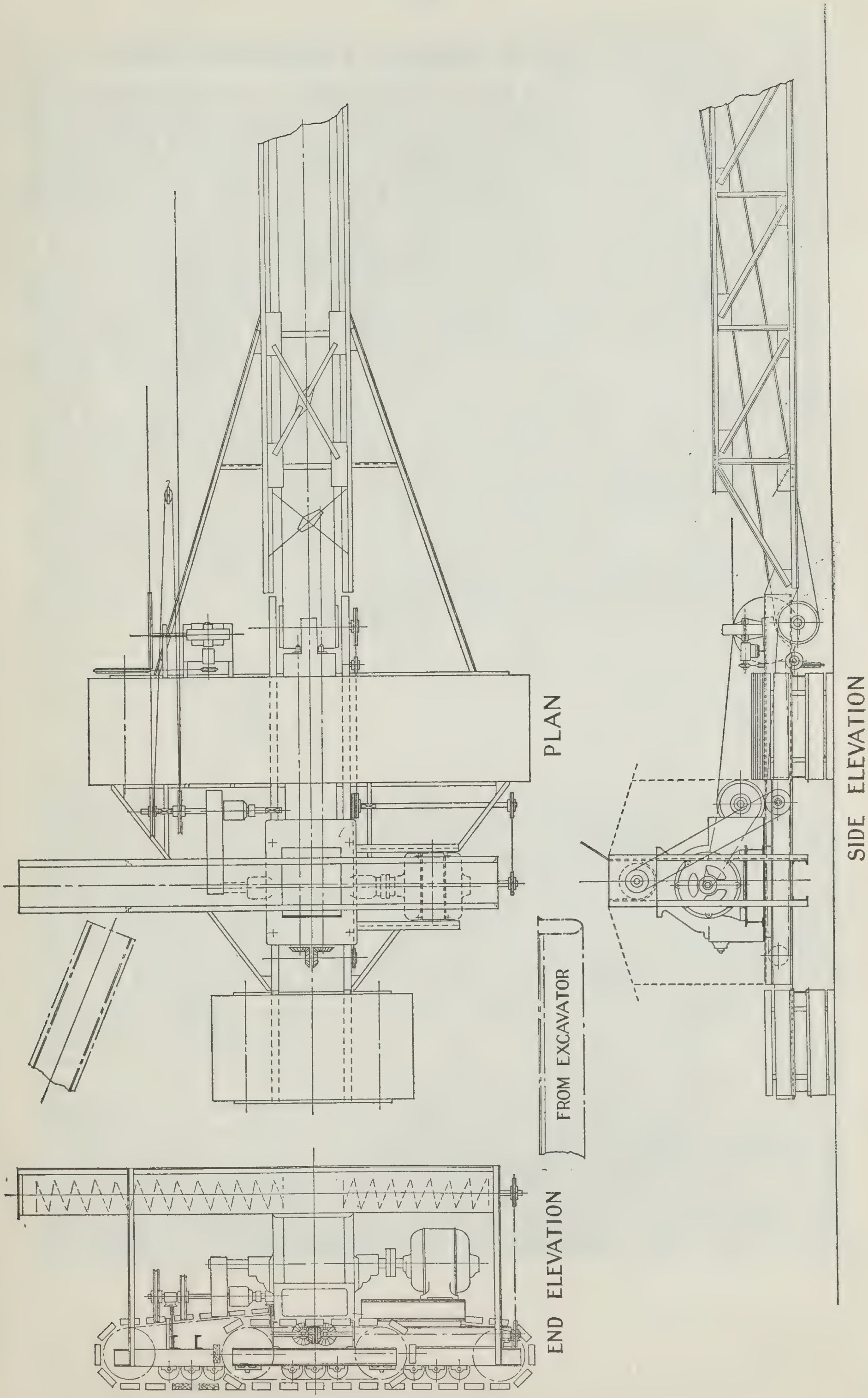


FIGURE 29. Plant No. 4 re-designed—inside end of belt

Capacity of the Re-designed Combination Plant

The total capacity of a peat plant is a function of the capacity of its weakest element, e.g., the capacity of Plant No. 4, the combination Anrep-Moore plant, was limited by the amount of peat which could be macerated in the hammer mill, this in turn was limited by the power available. Inasmuch as it was the desire of the Peat Committee to maintain an average capacity of 10 tons of saleable peat fuel per hour, during the entire season, efforts were made to ascertain what might be expected from a complete and balanced plant. This necessitated a determination of the average time which, it might be expected, would be lost due to weather conditions, and to stoppages due to accidents and breakages. The time necessary to move the plant at the completion of a row was reduced to seven minutes. Estimating an average production of between 15 and 16 tons of fuel from each row, the necessary aggregate time thus lost in producing 20,000 tons would be about 150 hours. Turning around the ends of the excavation it was determined, would require 150 hours during an entire season, thus, the total time for turning and moving would be 300 hours. During the entire period during which the Peat Committee conducted operation, the time lost due to weather conditions may be assumed to be 60 hours, that is three 20-hour days. Loss of time due to plant troubles as determined by observing the operation of the combined plant in 1922 was reduced to less than 9 per cent of the operating period. For a working season of 100 days and nights, or a total of 2,000 hours, the time lost and its distribution would be as follows:—

Moving the conveyer	7·5%	of the total time
Moving around ends	7·5%	" "
Weather conditions	3·0%	" "
Plant troubles	9·0%	" "
Total lost time	27·0%	" "

It will thus be observed that about 73 per cent of the total available season is left for manufacturing 20,000 tons of saleable fuel. In order to produce this quantity and allow for a 5 per cent waste in harvesting and 5 per cent in loading and storage, $20{,}000 \times \frac{100}{90} = 22{,}222$ tons must be laid down on the drying-ground in 73 per cent of the working season or, in $2{,}000 \times \frac{73}{100} = 1{,}460$ hours. To obtain this total quantity of fuel per season would, therefore, require an actual working capacity of slightly over 15 tons of fuel per hour for each element of the plant for 1,460 hours.

To ensure that the re-designed plant will have a sufficient maximum capacity to permit an average output of over 15 tons per hour to be maintained for 1,460 hours, the capacity of the excavator element has been increased more than 50 per cent and the power doubled. The spiral conveyer for transportation of the raw peat from the excavator to the pulverizer has been increased in size over 25 per cent. The other element which it was ascertained was undersize, namely, the swing hammer pulverizer which was 30 × 24 inches and was capable of handling peat at the rate of 11 gross tons per hour, will be replaced by a 36 by 24-inch mill, having a capacity practically double that of the one previously used. This larger type of mill should not require more than 75 h.p. to operate it,

but to ensure that its maximum capacity will be maintained a 100 h.p. motor will be provided. The capacity of the conveyer and spreading system employed with the combination plant which was thoroughly tried out, was ample, in fact, these elements were capable of handling double the quantity of macerated peat delivered to them. The limiting element of the spreader was the quantity of power available to drive it. This was supplied by a 10 h.p. gasoline engine; the spreader of the re-designed plant will be provided with a 20 h.p. electric motor.

Although a plant has not yet been constructed and operated according to these designs, it is expected that no trouble will be experienced in obtaining an average capacity of over 15 tons of standard peat fuel per hour when in actual operation, and it is estimated that with this average capacity, a production of 100 tons of saleable peat fuel per 10 hours for 100 days will be easily maintained, including all stoppages and allowing 10 per cent for wastage.

The plant just described is of general design, and the dimensions will naturally have to be altered to suit the bog on which the plant is to be installed. For example, if the bog selected for operations has an average depth of only 6 feet, the excavator frame will have to be altered to afford a longer cutting-face, or the length of the belt conveyer will have to be shortened to correspond to the smaller quantity of peat excavated per linear foot of travel. The usual variation in the depth of a bog due to uneven floor is already provided for, since the receiving hopper on the conveyer is made 18 feet long, although the average length of travel of the excavator for a row at Alfred was only 13½ feet. It would, therefore, be possible to lay a full row with the plant, as herein described, when operating on a bog with a depth varying from 5 to 9 feet in depth. For the former depth, the rows would have to be spread farther apart.

Every element of the re-designed combination Anrep-Moore plant, or Plant No. 4, has been tried out in actual operation over an extended period and defects observed. The construction of the entire re-designed machine is rugged and should stand up under continuous operation for many years. Practically all of the parts are standard and can be readily purchased. The plant resembles the ordinary machinery used by contractors for the moving and loading of such materials as earth with the exception that, on account of the low specific gravity of peat, the ease with which it is excavated and its freedom from hard lumps and abrasive matter, it can be made much lighter. The caterpillar aprons are of standard design and are larger in proportion to the weight carried than would be required for harder ground. The entire plant is portable and can be moved from one part of a bog to another under its own power, or from one bog to another by dismantling.

SUMMARY OF CONCLUSIONS

1. The only methods or processes which can be economically employed for the manufacture of peat fuel are those employing air-drying.

2. Climatic conditions in Ontario and Quebec (acute fuel area) are favourable for the manufacture of peat fuel on account of moderate rainfall, long summer days, and the comparatively high temperature.

3. The manufacture of air-dried machine-peat fuel can be carried on in these provinces for 100 days, from the early part of May to the latter part of August. Continuous operation is impossible on account of the severe frost during the winter months.

4. A peat bog should be drained only sufficiently to provide a firm surface for supporting machines, harvesting tracks, etc., and to provide a suitable area for spreading and drying the macerated peat.

5. The quantity of fuel produced on any bog during the working season is limited by the length of the working-trench and the width of the drying-area available. The maximum width of the drying-area which can be utilized economically is limited by the maximum length of the portable belt conveyer which can be employed to the best advantage. The length of the portable belt conveyer is limited mechanically, and the maximum length appears to be about 800 feet.

6. The rate of drying of the macerated, spread peat is influenced by the thickness of the spread, to a certain extent by the degree of maceration, and by weather conditions. The maximum thickness of the spread during the earlier portion of the season, and up to the end of June, is 6 inches. Thereafter the maximum thickness should not be more than $4\frac{1}{2}$ to 5 inches.

7. Under the average weather conditions prevailing in the provinces of Ontario and Quebec during the summer months, it is possible to obtain two complete spreadings of the drying-area in each season.

8. The use of caterpillar aprons for supporting heavy machinery on the surface of a peat bog is far more efficient than the old method of supporting machines on rails and ties.

9. A swing hammer pulverizer is more efficient and satisfactory for carrying out the operation of maceration than the conventional types of macerators heretofore employed.

10. The portable belt conveyer designed and operated by the Peat Committee proved highly efficient.

11. Labour costs with the combined Anrep-Moore plant designed by the Peat Committee were reduced to a minimum in relation to the capacity and output of the machine.

12. The most expensive item in the manufacture of air-dried machine-peat fuel is that of harvesting the dried peat. Mechanical appliances have been devised which effect important economies in the carrying out of the operations involved, but the actual picking up of the fuel from the drying-ground must still be accomplished by manual labour.

13. The total cost of a ton of peat fuel is greatly influenced by the overhead costs, and successful commercial operations are, therefore, dependent largely on strict business management.

14. The peat fuel produced by the Committee at Alfred was of good quality, and was suitable for domestic, industrial, and other purposes.

15. The fines produced in screening the fuel before loading on cars for shipment are not to be considered as a waste product, since they are of value for use in the manufacture of commercial fertilizers and for other purposes, and may, according to market conditions, command prices equal to or even higher than that of the fuel itself.

16. Owing to the high cost of transportation the limit to which peat can be shipped to advantage, under present freight tariffs, is approximately 100 miles.

17. Peat is a most admirable fuel for utilization in producer-gas plants, either of the non-by-product recovery, or by-product recovery types, and is also suitable for steam-raising when the cost is low enough to permit the fuel to be used in competition with coal.

18. The commercial production of peat fuel on a large scale can be conducted on many of the bogs which have been examined in detail, and which are favourably situated with regard to inhabited communities and transportation facilities.

PART III

CHAPTER IX

UTILIZATION OF PEAT FUEL FOR PRODUCTION OF POWER

PRODUCER-GAS POWER PLANTS

The production of power through the media of producer-gas plants offers an extensive field for utilization of peat from the bogs of Canada, more particularly those located at a distance from points where water-power can be developed at low cost.

Under an ordinary steam boiler, air is supplied to the fire in excess of the amount required for complete combustion, in order that the energy of the fuel may be converted rapidly into heat for the raising of steam. In the gas producer only sufficient oxygen is admitted to maintain temperatures high enough to convert the greater part of the carbon and hydrogen contained in the fuel into permanent combustible gases. These gases are directly burned in an internal combustion engine for the production of power, or further treated for recovery of commercial by-products. Carbon burned to form carbon monoxide produces only 4,400 B.T.U. per pound, but with complete combustion, carbon dioxide is formed producing 14,500 B.T.U. per pound. Under the steam boiler, therefore, the objective is complete combustion with formation of carbon dioxide, but in the gas producer formation of carbon monoxide is sought, since the heat energy stored in the gas can be much more effectively utilized in an internal combustion engine than under a steam boiler.

There are two principal methods at present employed for the utilization of peat in gas producers:—

(1) Gasification in a producer not constructed for recovery of by-products: hence a producer designed to convert the fuel into gas with the highest possible thermal efficiency.

(2) Gasification in a producer designed for the recovery of commercial by-products. In this case the commercial products obtained may be regarded as the principal products, and the gas produced as the by-product.

Both types of producers using peat fuel are in commercial use in Europe.

NON-BY-PRODUCT RECOVERY PRODUCER

The general practice of converting the energy stored up in fuel into useful work by burning it under a boiler and utilizing the expansive power of the resulting steam in an engine, is a wasteful and inefficient method.

Using coal with a calorific value of 12,500 B.T.U. per pound an ordinary 250 h.p. steam plant requires a minimum of 5 pounds of fuel per brake horsepower hour, which for a horsepower year of 6,000 hours amounts to 15 tons. A modern gas-producer power plant consumes only about 1½ pounds of coal per brake horsepower hour requiring 4½ tons of fuel per horsepower year of 6,000 hours.

Where peat fuel containing 25 per cent moisture and having a calorific value of 6,750 B.T.U. per pound is burnt in a gas producer, 2½ pounds are required per brake horsepower hour, or a total quantity of 7½ tons per horsepower year of 6,000 hours.[1]

On the basis of this comparison 500,000 tons of peat fuel burned in gas-producer plants for power production could replace 1,000,000 tons of coal, as used in ordinary small steam plants.

Even compared with the use of coal in the most perfect and skilfully operated steam plants, the utilization of peat fuel in gas-producer power plants is advantageous from an economic standpoint.

In a small Körting peat gas-producer plant erected about 1904 at Burangsburg, Sweden,[2] the average daily fuel consumption for a period of two years is reported to have been 2,354 pounds of peat containing 25 per cent moisture equal to 2·18 pounds per brake horsepower hour. In a producer-gas power plant at Nymphenburg, in a trial run, a consumption of 2·3 pounds peat per brake horsepower hour was obtained. The peat used had a calorific value of 5,857 B.T.U. per pound and the gas produced, 114 B.T.U. per cubic foot.

(For a description of other plants see "Peat and Lignite" by E. Nystrom.)

According to Davis the following yields and calorific values of producer gas per ton of peat have been observed.[3]

TABLE XIX

Yield and Calorific Value of Producer Gas per Short Ton of Peat

Gas producer	Source of peat	Yield of producer gas	Calorific value per cu. ft. of gas	Per cent of water in peat	Authority
		Cu. ft.	(B.T.U.)		
Mond	Italy	48,000	152·0	Water free	Nystrom
Körting suction	Germany	54,000	150·0	26	Ryan
" "	Sweden	80,000	....	....	Kerr
Mond	England	80,000	145·0	Water free	Nystrom
Ziegler pressure	Germany	97,200	135·0	....	Ryan
Loomis-Pettibone down-draft	North Carolina	72,400	109·7	Water free	U.S. Geol. Survey
Taylor pressure No. 7	Florida	76,600	175·2	Water free	U.S. Geol. Survey

[1] The Utilization of Peat Fuel for Power, by B. F. Haanel, No. 154, Mines Branch, Dept. of Mines, Canada.
[2] Peat and Lignite, by Erik Nystrom, No. 19, Mines Branch, Dept. of Mines, Canada.
[3] The Uses of Peat for Fuel and Other Purposes, by Chas. A. Davis, U.S. Bureau of Mines, Bulletin No. 16, 1911.

PEAT GAS-PRODUCER TRIALS

In 1910 and 1911 an investigation was conducted at the Fuel Testing Station of the Department of Mines, Ottawa, to ascertain the possibilities of utilizing peat as a fuel for the production of power in a producer-gas plant. The results of this investigation, which was made the subject of a special report[1] published in 1912, may be briefly summarized as follows:—

A 60 h.p., double zone, Körting peat gas producer was installed with wet coke scrubber, tar filter and dry scrubber, a Westinghouse 100 h.p. bituminous suction gas producer, complete with exhauster, wet scrubber, gas receiver and moisture separator and a 60 h.p. 4-cycle, single-acting, Körting gas engine.

Previous to the installation of the gas producers about 70 tons of peat fuel, for experimental purposes, had been manufactured at the Victoria Road peat bog near Lindsay, Ont. After remaining stored under cover at the bog for more than a year, the peat was shipped to Ottawa, and was used for making several tests for fuel consumption. Owing to long storage under cover the peat was too dry for efficient utilization in the Körting producer, and also the ash content was high, averaging about 10 per cent. These unfavourable conditions, together with the excessively high internal temperature obtained due to the dryness of the fuel, caused some troubles in operation, since the Körting gas producer was not provided with a vaporizer for the introduction of steam. The tests demonstrated, however, that, even with these unfavourable conditions, the plant could be successfully operated on a commercial basis. Three tests were made with this peat to determine the fuel consumption per brake horsepower hour, but the gas was not analysed or metered, as equipment for this work had not been installed at the time.

Summary Statement of Three Tests with Peat from Victoria Road

	I	II	III	
Duration of test, hours	7·5	12	10	
Average b.h.p. developed	58·9	58·0	61·8	
Moisture content of fuel	13	13	13	per cent
Ash content of dry fuel	10	10	10	
Calorific value of dry fuel	8650	8650	8650	B.T.U.per pound
Total fuel as fired	904	1704	1234	pounds
Total fuel calculated dry	786	1482	1074	"
Fuel consumption per hr. as fired	120·5	142	123·4	"
Fuel consumption per hr. calculated dry	104·9	123	107·4	"
Fuel consumption per b.h.p. hr. as fired	2·04	2·45	1·99	"
Fuel consumption per b.h.p. hr. calculated dry	1·78	2·12	1·73	"

Analysis of Victoria Road Peat

Volatile matter	69·5 per cent
Fixed carbon	25·2 " "
Ash	5·3 " "
Calorific value of dry fuel	8650 B.T.U. per pound.

The high amount of ash (10 per cent) in the peat used during the trials was due to a large amount of free sand contained.

[1] Report on the Utilization of Peat Fuel for the Production of Power, by B. F. Haanel, No. 154, Mines Branch, Dept. of Mines, Canada.

After the completion of the chemical laboratory, tests were begun with peat manufactured at the Government plant at Alfred, Ont. Experiments were conducted to ascertain the size to which peat should be crushed in order to obtain the best results in the producer. It was found that peat containing 30 per cent moisture should be crushed to about the size of a hen's egg, but if the peat contains less moisture, larger sizes may be used.

Summary Statement of Five Tests with Peat from Alfred, Ont.

Load—	Full	¼	½	¾	Full
Duration of test........hours	30	10	10	10	10
B.h.p. developed........ "	58·2	16·1	32·7	53·6	60·1
Moisture content of fuel........per cent	29·3	37·5	31·8	33·3	35·0
Ash in dry fuel........ "	6·0	6·0	6·0	6·4	6·1
Calorific value of dry peat....B.T.U. per pound	9470	9460	9460	9440	9500
Total fuel fired........ " " "	4900	965	1060	1580	1555
Fuel consumption per hr...... " " "	163	96·5	106	158	155·5
Fuel per b.h.p hr. as fired.... " " "	2·81	6·14	3·25	2·95	2·59
Fuel per b.h.p. hr. as calculated to 25% moisture...... " " "	2·65	5·12	2·95	2·62	2·24
Fuel per b.h.p. calculated dry " " "	1·98	3·84	2·22	1·97	1·68

Average Analysis of Dry Peat from Alfred

Volatile matter........	63·1 per cent
Fixed carbon........	30·8 " "
Ash........	6·1 " "
Calorific value........	9460 B.T.U. per pound

As a result of these trials, changes in the internal construction of the producer were recommended to the manufacturers, and these were carried out under their superintendence. A cleaning system was also devised by the writer which effectively separated the troublesome tarry matter from the gas.

After these alterations had been completed a further series of tests were conducted. Results of same appear in the accompanying tabulated statement and are given in greater detail in the report cited.

TABLE XX

Results of Peat Gas-producer Trials

No. of trial	20	21	24	28	29	30	31	32	33	34	35	36	Full load average	¾ load average
Load	full	full	¾	¾	¾	¾	¾	¾	¾	¾	¾	¾		
Duration of test ... Hrs.	10	20	10	8	8	8	8	8	8	8	8	8		
Average brake horsepower developed	53·8	53·7	41·3	45·0	45·7	47·4	46·9	46·2	45·8	45·1	45·9	45·8	53·75	45·5
Proximate analysis of dry peat:														
Fixed carbon ... %	29·5	30·0	29·9	31·3	31·3	30·0	30·0	30·0	30·4	30·4	30·4	30·4	29·7	30·4
Volatile matter ... %	64·8	64·6	65·1	63·8	63·8	65·3	65·3	65·3	64·8	64·8	64·8	64·8	64·7	64·8
Ash ... %	5·7	5·4	5·0	4·9	4·9	4·7	4·7	4·7	4·8	4·8	4·8	4·8	5·6	4·8
Calorific value of dry peat ... B.T.U. per lb.	9470	9450	9730	9450	9450	9500	9500	9500	9400	9400	9400	9400	9460	9470
Calorific value of peat as charged ... "	6500	6600	7020	7270	7270	7270	7270	7270	7310	7310	7310	7310	6550	7260
Moisture in peat as charged ... %	31·4	30·2	27·8	23·1	23·1	23·5	23·5	23·5	22·2	22·2	22·2	22·2	30·8	23·33
Total fuel fired ... lb.	1250	2450	1102	974	1030	1040	1055	933	838	868	857	958	1237	965·5
Gas analysis by volume:														
Carbon dioxide ... %	10·8	9·9	8·5	....	5·1	9·0	9·9	6·55	5·9	4·8	8·3	6·5	10·35	7·17
Ethylene ... %	0·5	0·4	0·4	....	0·4	0·1	0·4	0·15	0·4	0·2	0·3	0·5	0·45	0·32
Oxygen ... %	0·5	0·3	0·3	....	0·4	0·2	0·4	0·25	0·2	0·5	0·4	0·7	0·4	0·37
Carbon monoxide ... %	17·7	20·2	22·4	....	26·8	20·7	19·3	24·65	26·3	26·9	22·4	24·4	18·95	23·76
Methane ... %	2·4	2·4	2·1	....	1·7	1·9	2·4	2·05	1·9	2·0	2·0	2·9	2·4	2·1
Hydrogen ... %	10·2	10·3	10·0	....	4·7	10·6	10·9	8·85	9·1	7·4	8·8	7·5	10·25	8·65
Nitrogen ... %	57·9	56·5	56·3	....	60·9	57·5	56·7	57·5	56·2	58·2	57·8	57·5	57·2	57·6
Inflammable gas ... %	30·8	33·3	34·9	....	33·6	33·3	33·0	35·7	37·7	36·5	33·5	35·3	32·05	34·8
Calorific value from analysis (gross) ... B.T.U. per cu. ft.	122	128	132	....	124	121	128	130	139	133·5	125	138	125	130
Calorific value from analysis (net) ... "	113	120	124	....	120	114	120	123	132	127·5	118	131	116·5	123·3
Net calorific value from calorimeter ... "	123	127	129	....	130	121	124	130	138	133	127	134	125	129·6
Fuel consumption per hour ... lb.	125	122	110	122	129	130	132	117	104	108	107	120	123·5	117·9
Fuel consumption per kw. hour ... "	3·54	3·47	4·06	4·14	4·30	4·18	4·29	3·86	3·47	3·65	3·55	4·0	3·5	3·95
Fuel consumption per b.h.p. hour as fired. "	2·32	2·27	2·66	2·71	2·82	2·74	2·81	2·53	2·27	2·40	2·33	2·62	2·295	2·59
Fuel consumption per b.h.p. hour calculated dry ... "	1·6	1·6	1·91	2·09	2·16	2·09	2·15	1·93	1·77	1·86	1·81	2·03	1·6	1·98
Gas produced per lb. of dry peat ... cu.ft.	53·4	52·6	48·6	....	....	....	....	....	....	....	....	....	53	....
Gas produced per lb. of dry peat (heat equivalent) ... B.T.U.	6040	6310	6030	....	....	....	....	....	....	....	....	....	6175	....
Gas delivered per b.h.p. hour (heat equivalent) ... B.T.U.	9660	10100	11500	....	....	....	....	....	....	....	....	....	65·3	....
Producer efficiency ... %	63·8	66·8	62	....	....	....	....	....	....	....	....	....	....	....

The general results of the tests showed the fuel consumption per brake horsepower hour to be: for full load 1·7 pounds of dry peat or 2·3 pounds of peat containing 25 per cent moisture; for three-quarter load, including standby losses, 2·1 pounds of dry peat or 2·8 pounds of peat containing 25 per cent moisture. Assuming that peat with a moisture content of 25 per cent could be delivered to the plant at a cost of $2.00 per ton, and that the plant is run with a load factor of 75 per cent for 3,000 hours, the fuel costs would be $8.40 per b.h.p. year, including standby losses.

In the final series of tests made at the Fuel Testing Station, using peat fuel with an average moisture content of 30·8 per cent and a calorific value of 6,550 B.T.U. per pound as fired, the yield of producer gas was 73,300 cubic feet per short ton with a calorific value of 125 B.T.U. per cubic foot. For three-quarter load using peat fuel with a moisture content of 27·8 per cent and a calorific value of 7,020 B.T.U. per pound as fired, the yield of gas was 70,180 cubic feet per ton with a calorific value of 129 B.T.U. per cubic foot.

The situation as regards utilization of peat fuel for power production in gas-producer plants may be briefly summarized as follows:

Utilization of a fuel when burned in gas-producer plants is much more efficient than when burned under a boiler for the operation of a steam engine. The process of making producer gas is well established, and engines for utilizing the gas are already developed to a high state of efficiency. Peat is a highly suitable fuel for use in producer-gas plants. Such use of peat would be a valuable economic measure in conserving coal, and decreasing our dependence on imported fuels. Although the initial cost of a power plant with gas producers and producer-gas engines is higher per horsepower than with boilers and steam engines, this is more than offset by marked economies in operation. Peat gas-producers for power purposes should, wherever possible, be erected on the bog and the energy generated either utilized on the spot, or transmitted in the form of electricity, as in the case of central power plants.

BY-PRODUCT RECOVERY GAS PRODUCERS

The method of utilizing peat by burning it in gas producers, specially designed for the recovery of by-products, is dependent for commercial success not only on the quantity and character of such by-products, as well as cost of their extraction, but on the existence of ready and profitable markets which will absorb them as they are produced.

In order to secure the most favourable results from the use of peat in a gas producer for recovery of by-products, the peat must be delivered to the producer in a form suitable for firing. In European practice the best results have been obtained by the use of machine-peat fuel with a moisture content in the vicinity of 33 per cent. The establishment of a peat fuel industry so that ample supplies of machine-peat will be readily available, is a necessary preliminary to an undertaking having for its main objective the recovery of commercial by-products from peat.

In Canada, and especially in the provinces of Ontario and Quebec, it is, generally speaking, in the interest of economy to aim at the complete gasification of all the heat elements in the fuel. Certain bogs, however, are exceptionally rich in nitrogen content, and may prove a practical source for the production of sulphate of ammonia, a valuable fertilizer.

Ten of the bogs examined in Ontario, which have a total fuel content of 43,000,000 tons of 25 per cent moisture peat, are estimated to contain 787,000 tons of nitrogen, which with 70 per cent recovery are capable of yielding 1,800,000 tons of ammonium sulphate with a gross value at pre-war prices of about $130,000,000. In addition to the ammonium sulphate, there would be produced a quantity of producer gas sufficient to generate approximately 40,000 horsepower continuously for 100 years.

BY-PRODUCT RECOVERY PRODUCER PLANTS ERECTED IN EUROPE

Orentano, Italy

This plant is located on a bog of 1,480 acres extent situated near the village of Orentano, Italy.[1] The bog has an average depth of 1½ metres (5 feet) of good peat fuel. The deposit is not continuous in depth but is divided by a parting layer of gravel and clay about a foot thick into two equal layers. This circumstance and the fact that the bog is low-lying and must be drained by pumping seriously militate against the economic winning of the peat.

Average ash content of the fuel used in the producers, taken almost altogether from the upper layer of peat, was 12 per cent, and nitrogen content 1·56 per cent on dry sample. As fired, with a moisture content of 32 to 33 per cent, the nitrogen content would average about 1·05 per cent.

Under the conditions existing at Orentano, economic operation was only possible on account of the low cost of labour. The plant operation was conducted in two shifts of 12 hours each, the average daily wage of employees in the producer plant being slightly over 2 lire (about 65 cents) per day.

The greater portion of the fuel used in the producers was dug by hand, mechanically treated and artificially dried at the plant by the heat of the gas-engine exhaust supplemented by the burning of fuel in a special air-heater. The remainder was air-dried on the bog.

Five Dolberg peat machines were employed for manufacturing the fuel. Each machine required a complement of 13 men. The power-gas plant consisted of a battery of 4 producers, 3 of the Mond type and one of the Cerasoli type.

In the latter an attempt was made to utilize within the producer itself a portion of the water contained in the peat, to reduce the quantity of steam that it is necessary to supply. The producer was internally divided into three compartments by means of two partitions supported by arches and extending from the producer top, one to within a short distance from the fire bars, the other partition being considerably shorter.

[1] Peat, Lignite and Coal, by B. F. Haanel, No. 299, Mines Branch, Dept. of Mines, Canada.

Air was admitted through the fire bars for a distance equal to one-third of the circumference of the producer—the remaining two-thirds being solid—whereby combustion in the first chamber was much greater than in the second, about two-thirds of the fuel charged being burned in the first chamber. The moisture evaporated from the peat in the first chamber passed down and through the incandescent carbon in the lower portion of the producer, reacting with it to form carbon dioxide or carbon monoxide and hydrogen. Since two-thirds of the volatile matter and moisture of the total fuel charged reacted with the incandescent carbon, it was theoretically possible to reduce the quantity of steam supplied for the air-blast, thus increasing the thermal efficiency of the producer. The power equipment consisted of two gas engines of 350 horsepower each, driving two A.C. generators which at 750 r.p.m. generated current at 6,000 volts.

Total quantity of gas produced per metric ton of peat containing 15 per cent moisture was 56,860 cubic feet. Burning peat with 33⅓ per cent moisture the amount of gas would be 40,410 cubic feet per ton which was utilized as follows:—

For steam-raising	14,824 cubic feet
For drying peat	10,762 "
For power	14,824 "

The higher calorific value of the gas was 155 B.T.U. and the lower calorific value 138 B.T.U. per cubic foot.

Average composition of gas:—

Carbon dioxide (CO_2)	20·0 per cent
Carbon monoxide (CO)	9·5 "
Methane (CH_4)	3·5 "
Hydrogen (H)	24·0 "
Nitrogen (N)	43·0 "

The load developed at the electric generator was 200 kw. during the day, and 270 kw. during the night, both periods being of 12 hours' duration. Daily consumption of power at the plant was approximately 70 kw. and the electrical energy sold to consumers was on an average 165 kw. per day—130 kw. during the day and 200 kw. during the night.

The productive capacity of the plant was 1,390 short tons of sulphate of ammonia per year of 350 days. At the time of investigation the plant was operating at less than normal capacity, the daily consumption of peat fuel being about 45·11 tons of 33⅓ per cent moisture peat, which with 70 per cent recovery, would yield 594 tons of sulphate of ammonia per year of 350 days.

The amount of sulphuric acid required at this plant was equal to 1·2 times the weight of the ammonium sulphate produced, or, as the plant was operated, 713 tons of sulphuric acid, 50° Bé.

Estimated cost of annual operation, including supply of peat fuel at $1.00 per ton	$ 59,370 00
Credit sale of 594 tons ammonium sulphate at $65.00 per ton	38,610 00
Net cost of power per annum	$ 20,760 00
Net cost per kw. hour of power sold to consumers (165 kw. hours for 350 days of 24 hours)	1·5 cents

This estimate does not include general office expenses, salaries of general manager and consulting engineer, and unforeseen expenses.

Power was sold to consumers at 20 centimes (3·86 cents) per kw. nour. No dividend had as yet been declared by the company up to the time of investigation of the plant. If the plant were operated at full capacity, however, the power would be generated free of cost.

Since the war, conditions in Italy have changed as regards costs of labour, plant, and industrial coal, and according to reports this plant has been closed down. The above is of interest, however, inasmuch as it shows to what extent an industrial plant utilizing peat fuel is dependent either on cheap labour or mechanical appliances to eliminate labour.

Codigoro, Italy

In 1904 a second plant for the manufacture of sulphate of ammonia from peat by the Mond process was established at Codigoro, Italy.[1]

The peat deposit worked was shallow having a maximum depth of only one metre, and prior to operation had been under cultivation. The ash content was high, being as much as 20 to 30 per cent. It was, however, easily worked, the surface having been reduced to powder by the action of the sun and yearly ploughing. Its average moisture content was about 60 per cent, and the specific gravity of the peat about 0·70. Excavation, transportation, and drying were therefore easy and economical, and industrial treatment was consequently greatly facilitated. At the outset excavation was performed by hand, but later a mechanical excavator, specially designed by Dr. Wielandt of Oldenburg, Germany, operated by electricity was employed. The excavator performed work equivalent to the labour of thirty men, excavating over 600 cubic metres per 10-hour day.

The peat was artificially dried, the moisture content being reduced from 60 to about 30 to 35 per cent. Drying was effected by means of the hot products of combustion of gas or tar recovered from the peat in the gas-producer plant, supplemented by heat from an additional furnace. The driers were adapted to evaporate up to 200 tons of water daily. Six gas producers were installed, each capable of gasifying 30 tons of peat per 24 hours. With a consumption of 150 tons of peat daily, 270,000 cubic metres of gas of about 1,400 calories per cubic metre could be produced. About 80 kilograms (176 pounds) of sulphate of ammonia could be produced per ton of peat, or a total of about 26,400 pounds per day, with a consumption of about 33,000 pounds daily of sulphuric acid at 56° Bé. The acid was made at the plant.

A central electric plant furnished the energy required for all the services of the plant.

It was calculated that the gas produced from 50 to 60 tons of peat would be required for the daily production of steam, but 30 to 40 million calories are recovered daily in the products of combustion which are utilized for the drying. The total power consumption of the installation for all purposes is about 7,000 kw. hours daily.

After removal of the peat the surface of the bog was ploughed and after application of suitable chemical fertilizers, was utilized as agricultural land.

[1] Translat on from Il Monitore Tecnico—Journal of the Canadian Peat Society, Vol. IV, No. 1.

Schweger Moor, Germany

In 1910-11, the German Mond Gas and By-Products Company erected a by-product recovery power-gas plant on the Schweger Moor near Osnabruck, Germany.[1] Before commencing operations the company entered into a contract with the city of Osnabruck to supply power continuously for various purposes. The bog obtained was wet, and sufficient time was not available for properly draining it. Consequently when operations were commenced great difficulty was experienced in manufacturing the necessary supply of peat fuel. The nitrogen content of the peat used was too low—1 per cent—to give satisfactory results. The conditions for manufacturing peat were most unfortunate, and the company was forced to supply the plant to a certain extent with peat bought from manufacturers on a small scale, at an average cost said to be in the neighbourhood of $3.50 per metric ton. These adverse conditions led to the establishment of a steam-power plant operated with coal to be employed as an auxiliary or substitute plant. Later on the by-product recovery plant was closed down indefinitely.

The plant was designed to employ the Frank-Caro process for which the claim was made that the maximum quantity of power gas with maximum recovery of ammonia could be obtained from peat with upwards of 60 per cent moisture content.

Since the operations were conducted in great secrecy, no information other than that obtained by direct observation could be secured. Calculations based on theoretical considerations shown elsewhere in this report, however, clearly indicate that the results claimed to have been obtained at the Osnabruck gas-power plant could not possibly be realized by burning peat containing 60 per cent water.

The only important difference between the Mond and Frank-Caro processes is in the method of recovering the sensible heat of the gases—both producer and boiler flue gases.

The Mond process makes use of the fact that a low temperature and the presence of steam in gas producers are conducive to the formation of ammonia. Hence a limited supply of air charged with a large quantity of steam is introduced into the producer. The sensible heat of the gas is abstracted by the cold water introduced in the gas cooling-tower. The water becomes heated and is introduced into another tower where its heat and some moisture are imparted to the air blast which is forced through the tower. Since the temperature of the exit gases from the producers is necessarily low, no attempt is made to utilize it by means of superheaters. All additional moisture required is obtained by introducing live steam into the air blast main.

The Frank-Caro process does not utilize the sensible heat of the producer gas in this way, but passes the air blast over hot water contained in thermal reservoirs or tanks. The hot water supplied to these tanks is obtained from special economizers placed in the stack of the boiler plant.

[1] Peat, Lignite and Coal, by B. F. Haanel, No. 299, Mines Branch, Dept. of Mines, Canada.

The waste heat of the boiler furnaces is, therefore, utilized instead of the sensible heat of the producer gas. The air blast after passing through the thermal tanks enters the producers at a point about one-third the height of the producer above the ground level. This section of the producer is jacketted, and the air blast in passing down to the grates must first fill this annular space, which is situated in the hottest portion of the producer, and its temperature is consequently raised. The additional steam required for saturating the air blast is supplied by a battery of boilers which are heated by burning peat and the tar resulting from the process of gasification.

In the plant on the Schweger Moor, five producers were installed, which were estimated to be capable of producing a quantity of gas sufficient to generate 3,000 h.p.

The power plant consisted of four 1,000 h.p. gas engines—one held in reserve. Electric energy was distributed at 30,000 volts. The heat of the gas engines exhaust was utilized for generating steam in low-pressure boilers, decreasing to a considerable extent the quantity of steam necessary to be generated in the main boiler plant. Both the Strenge and Dolberg systems were employed for the manufacture of peat fuel.

From a report by Dr. Hamers[1] the following results of operation were obtained.

TABLE XXI

Operating Data of Mond By-product Recovery Plant on Schweger Moor

—	Tons	December 1912	January 1913	February 1913
Wet peat gasified	metric	1325	1454	930
	short	1457	1599	1023
Moisture content of peat, per cent		60	58	41
Absolutely dry peat gasified	metric	530	611	549
	short	583	672	604
Peat burned under boilers	metric	170	200	107
	short	187	220	118
Absolutely dry peat burned under boilers	metric	68	84	63
	short	75	92	69
Tar burned under boilers				
Sulphate of ammonia	metric	18·3		19·5
	short	20		21·45
Recovery per metric ton of dry peat	kilograms	34·5		35·5
" " short ton of dry peat	lbs	69		71
Nitrogen content of peat, per cent		1		
Total quantity of absolutely dry peat consumed	metric tons.	598	695	612
	short	658	764	673
Total power developed kw. hours		427,000	481,000	414,000
Power developed per metric ton dry peat "		715	692	676
" " per short ton of dry peat "		650	629	615

The quantity of tar burned under the boilers is not stated.

Production of sulphate of ammonia during the month of January was markedly reduced owing to an alteration of the sulphate plant being made during the month.

[1] Dr. Hamers. "Report on the results to date of the gas and electric plant in the Schweger Moor and the plans for its furthe ıdevelopment." See Minutes of the 68th Session of the Prussian Central Moor Commission, 1912, page 36.

In December, with peat containing 60 per cent moisture the production of ammonium sulphate is reported as being 69 pounds and of power 650 kw. hours per short ton of absolutely dry peat; while in February with peat containing 41 per cent moisture the ammonium sulphate produced was 71 pounds, and power 615 kw. hours per short ton.

From the above report it would appear that the high moisture content of the fuel burned during December (60 per cent) did not appreciably affect the production of power or of ammonia gas. Such a deduction cannot be entertained since both the heating value of the power gas, and the quantity of ammonia gas formed must vary with the moisture content; an increase in moisture causing a decrease in the quality of the power gas and in the quantity of the ammonia gas. Under the most ideal conditions the quantity of heat generated by the burning of peat containing 60 per cent moisture in a producer is not sufficient to effect the various reactions and provide for losses. It is, therefore, impossible to produce from peat containing so high a moisture content, a power gas of the calorific value claimed.

In order to obtain the best results, the writer believes that the moisture content of the peat fuel must be kept as low as 30 to 35 per cent. This opinion is based on the results obtained from other by-product recovery plants operating with peat and on the results of the investigation of the utilization of peat for power purposes, conducted in the laboratories of the Mines Branch.

PERMISSIBLE MOISTURE CONTENT OF PEAT FUEL FOR USE IN GAS PRODUCERS

For the formation of ammonia gas in the producer large quantities of steam must be introduced into the reaction zone to supply the necessary hydrogen to combine with the nitrogen of the fuel. Large quantities of heat are required to effect the reactions involved, to maintain the working temperature of the producer, and to provide for radiation and other losses.

These are easily supplied when the fuel gasified has a high calorific value, but with a low-grade fuel, such as peat, the quantity of heat is much less, and is still further decreased by a high moisture content.

In addition to the heat required to evaporate the moisture, a certain quantity is required to distil the volatile matter, a part of which is lost in this type of producer. The tarry matter which is distilled leaves the producer without taking any part in the formation of the producer gas, and since it possesses a high calorific value the heat lost to the process in this manner is considerable.

The steam introduced with the air blast must be raised to the temperature of the reaction zone where a portion of it is decomposed, liberating hydrogen and giving rise to the formation of carbon monoxide or carbon dioxide according to the temperature, but the larger portion escapes without parting with much of its heat. In addition, the heat of the ashes passing into the water seal, and the heat lost by radiation are considerable.

It is doubtful whether peat of 60 to 70 per cent moisture would burn at all under these conditions, where if a producer gas is required the combustion must be incomplete, and it is quite certain that the temperature of the combustion zone will in time fall to such a degree that only carbon dioxide will be formed and perhaps also a quantity of hydrogen. When this condition arises the steam in the air blast must be reduced.

In a report on the operation of the Mond gas plant at Osnabruck, Germany, a gas yield of 36·1 cubic feet per pound with a heating value of 140 B.T.U. per cubic foot (134 B.T.U.per cubic foot net) and a power production of 1,000 h.p. hours per ton of absolutely dry peat is said to have been obtained with peat containing 60 per cent moisture. The following calculation based on theoretical considerations, clearly shows this to be impossible. In this calculation a gas composition is assumed which will give a net calorific value of 131 B.T.U. per cubic foot.

The following assumptions are made:—

That all the peat substance is completely gasified.

That all the water in the peat is distilled off with the gas, undecomposed.

That all the air enters the producer, saturated at 60° C.

That all the steam introduced with the air is decomposed.

HEAT BALANCE

Entering the Producer:—

1. Potential heat units of wet peat fired = gross calorific value of wet peat.
2. Sensible heat (above 0° C.) viz. air + water at 60° C.
3. Latent heat of steam at 60° C.

Leaving the Producer:—

4. Potential heat units in gas generated = gross calorific value of gas.
5. Sensible heat of gases, including the steam, at 200° C., reckoned from 0° C.
6. Latent heat of steam in gases, at 0° C.
7. Radiation losses.

VALUES USED IN CALCULATION

H = 1, C = 12, N = 14, O = 16.
1 gramme-molecule occupies 22·4 litres at 0° C. and 760 mm.
Latent heat of steam at t° C. = 606·5 − 0·695t calories (Regnault).

Mean specific heats, at constant pressure:—

Air,	0°– 60° C.	= 0·237	Regnault
N_2	0°–200° C.	= 0·244	"
CH_4	0°–200° C.	= 0·593	"
H_2	0°–200° C.	= 3·409	"
CO_2	0°–200° C.	= 0·217	"
CO	0°–200° C.	= 0·453	Pier.

Gross calorific powers, in calories per gramme-molecule:—

$CO = 68,200$
$CH_4 = 213,500$
$H_2 = 69,000$

Analysis of peat burned:—

	Dry	60% H_2O
Carbon	56·0%	22·40%
Hydrogen	5·2 "	2·08 "
Nitrogen	1·9 "	0·76 "
Oxygen	30·9 "	12·36 "
Ash	6·0 "	2·40 "
Water	0·0 "	60·00 "

Calorific power:—

Calories per gramme	5,255	2,102
B.T.U. per pound	9,460	3,784

100 grammes of peat containing 60 per cent H_2O, 86·0 grammes of air, and 13·4 grammes of H_2O, can give in the producer, 2·40 grammes of ash 60 grammes of steam together with 66·82 grammes N_2+2·72 grammes CH_4+2·89 grammes H_2+ 46·93 grammes CO_2+17·64 grammes CO.

The permanent gases are:—

2·386 gramme-molecules N_2+0·170 gramme-molecules CH_4+ 1·445 gramme-molecules H_2 + 1·067 gramme-molecules CO_2+0·630 gramme-molecules CO.

Total 5·698 gramme-molecules, i.e., 127·6 litres.

The gas has the composition:—

N_2	41·88%
CH_4	2·98 "
H_2	25·36 "
CO_2	18·72 "
CO	11·06 "

Calorific value in B.T.U. per cubic foot moist at 60° F. and 30" mercury:—

Gross	147
Net	131

The air in order to carry with it the above proportion of steam must have been saturated at a temperature of about 60° C.

HEAT BALANCE

(1) =	210,220 calories.	(4) =	178,950 calories.
(2) =	2,027 "	(5) =	13,890 "
(3) =	7,570 "	(6) =	36,390 "
		(7) =	−9,410 "
Total...	219,820 "		219,820 "

The above calculations show that under the most ideal conditions —which do not and cannot obtain in actual practice—the quantity of heat generated by the burning of peat containing 60 per cent

moisture in a producer, is not sufficient to effect the various reactions and provide for losses. It is, therefore, impossible to produce from peat containing so high a moisture content, a power gas of the heating value claimed. It is more within the realm of probability that complete combustion would have to take place in order to permit the production of the necessary quantity of heat—in which case the gas resulting would contain no combustible components whatever, except perhaps a small percentage of hydrogen.

With the introduction, moreover, of the large quantity of steam with the air blast, which must be in excess of that theoretically required, it is quite probable that the temperature, as stated previously, would fall too low, even for the formation of ammonia gas.

In order to obtain the best results it would appear that the moisture content of the peat fuel must be kept as low as 30 to 35 per cent.

Strong confirmation of this is afforded by the fact that many large-scale plants constructed to utilize high moisture content peat have closed down.

FEASIBILITY OF ERECTING BY-PRODUCT RECOVERY PEAT PRODUCER-GAS POWER PLANTS IN CANADA

The successful establishment of a plant or plants in Canada for recovery of by-products from peat by using it in gas producers, is dependent on several factors.

(1) Availability of a sufficient supply of suitable peat fuel.
(2) Cost of peat supplied to the producer, and its nitrogen content.
(3) Labour costs.
(4) Plant costs.
(5) Cost of sulphuric acid laid down at the plant.
(6) Markets for power and by-products produced.

In operation of European plants of this description perhaps the most serious difficulties have arisen in securing the requisite quantity of peat fuel in suitable condition for use in a gas producer.

Although claims have been frequently made that peat containing as high as 60 to 70 per cent of moisture can be utilized in a gas producer for recovery of by-products, the peat used in commercially successful plants has had a moisture content of about 33⅓ per cent only.

It has been satisfactorily demonstrated that peat fuel with a moisture content of from 25 to 30 per cent can be manufactured in Canada during the summer season. The development of the necessary machines has been advanced to such a stage that a sufficient supply of peat may be readily assured by installation of as many units as may be required.

It is estimated that operating with a single unit plant, machine-peat fuel can be manufactured at the present time in Canada at a cost of $3.50 per ton, made up of $2.00 production cost and $1.50 overhead charges. With several units in operation on the same bog, under the same management and with a by-product recovery gas-producer plant, it is probable that the cost can be materially reduced.

For continuous operation of a gas-producer plant employment of labour in three 8-hour shifts must be reckoned upon. On this account the number of labourers required may exceed that necessary in European practice. Labour wage scales are also higher than those prevailing in Europe, both for skilled and unskilled labour. It must also be taken into account that the cost of machinery and buildings is higher in Canada than in Europe.

Until such time as local markets for large quantities of sulphuric acid exist, the necessary supply must be imported.

Prices obtainable for ammonium sulphate are controlled by the world market price which is dominated by European production. Plants established for its production in Canada must, therefore, enter into competition with foreign companies having the advantage of lower manufacturing costs.

Finally the question of the market for the power produced is one of great importance. Canada, especially in its eastern sections, is well supplied with water-powers, and the development of these is being vigorously prosecuted. Large water-power installations permit the development of electric power at a very low figure, and excepting at points where hydro-electric energy must be transmitted long distances, the competition of low-priced hydro-electric power must be met. Prior to actual installation of gas plants, therefore, a market must be established for power at such prices as will yield a reasonable profit.

CHAPTER X

PEAT FUEL FOR STEAM-RAISING

When burned under favourable conditions air-dried machine-peat fuel can be economically utilized for the production of power through the media of the steam boiler and steam engine.

Characteristics of peat which are favourable to its use for this purpose are:—

(1) It is free burning, and being rich in volatile matter burns with a long flame.
(2) It is almost smokeless when burned under proper conditions.
(3) It is generally low in ash.
(4) It burns to a light finely divided ash without formation of clinkers.
(5) It is usually entirely free from sulphur and the gases formed in its combustion do not attack metallic surfaces.

It possesses on the other hand, some unfavourable characteristics, viz.:—

(1) Comparatively low calorific value.
(2) Owing to bulkiness requires more frequent firing.
(3) High moisture content.

Boiler furnaces designed for the use of coal, either anthracite or bituminous, are not suitable for burning peat fuel to the best advantage. Quantity, admission and control of air supply, method of feeding the fuel, grate dimensions, and the depth of the firebox, its shape, general arrangement, and its position relative to the walls of the boiler must all be adapted to the peculiarities of peat fuel, if the maximum evaporative effect is to be obtained from its use.

Owing to its comparatively large content of oxygen, the amount of air theoretically necessary for complete combustion of peat fuel is much less than that required for coal.

TABLE XXII

Amount of Air Necessary for Burning One Kilogram of Various Fuels[1]

—	Carbon, kilograms	Free hydrogen, kilograms	Chemically bound water, kilograms	Theoretical amount of air required	
				kilograms	cu. metres
Anthracite	0·90	0·03	0·05	16·415	8·796
Coke	0·85 } 0·92 }	......	0·10 } 0·05 }	9·806 } 10·594 }	7·564 } 8·163 }
Wood charcoal air-dry (12% moisture)	0·85	......	0·12	9·796	7·554
Brown coal (20% moisture)	0·45	0·01	0·49	5·535	4·265
Air-dried machine-peat (18% moisture)	0·465	......	0·47	5·882	4·532
Air-dry wood (20% moisture)	0·40	......	0·59	4·619	3·560

[1] Handbook on the Winning and the Utilization of Peat, by A. Hausding.

The bulkiness of the fuel and its low calorific value necessitate more frequent firing than with coal. Where peat fuel is used in ordinary boiler installations the more frequent opening of the fire doors for feeding results in the admission of excessive amounts of cold air with resultant cooling of the boiler heating surface. Cooling by covering of the fire with fresh layers of fuel is also increased, and the heat wasted in evaporation of the high moisture content of the fuel as fired, is also an important item. For these reasons hand-fired boiler installations with flat grates are not suitable for burning peat.

More satisfactory results are obtainable from a furnace of the Dutch oven type, especially if divided into two compartments by a firebrick partition, the combustion gases from which unite either directly in front of, or over the bridge wall. The firebrick roof of the combustion chamber serves in this case as a heat reservoir which tends to equalize temperatures and minimize cooling by giving off stored heat to the fresh layer of fuel. By alternately firing the compartments of the furnace, one compartment may be filled with fresh fuel while the other is in active glow. Where such an installation is fed with fuel through hoppers in the roof of the combustion chamber instead of through the fire doors, the operation of charging the furnace is reduced to a few seconds, and the amount of cold air which enters is considerably reduced.

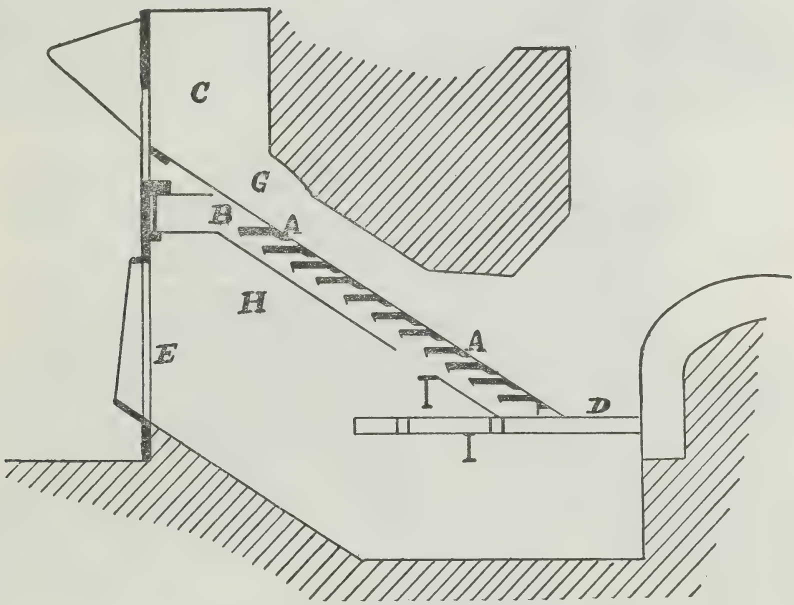


FIGURE 30. Step grate

Step grates are more efficient than the ordinary flat grates for burning peat. A step grate[1] (Figure 30) consists of a number of grate bars, A, placed like the steps of a staircase and supported at each end by cast-iron plates, B, inclined at an angle ordinarily of 40 to 45 degrees, and resting

[1] Peat and Lignite, by E. Nystrom, No. 19, Mines Branch, Dept. of Mines, Canada.

on a flat grate, D. The grate is filled with peat through the opening, C, and air is admitted from the space, H, to the openings between the bars of the step grate, and the peat as it is consumed settles down automatically.

The special construction of the Langen step grate (Figure 31) makes it possible to feed the fresh peat into the combustion chamber under, instead of over, the fuel already ignited.[1] The peat is thrown on the plates d_1, d_2, d_3, and pushed through narrow openings, and deposited on an inclined grate, at

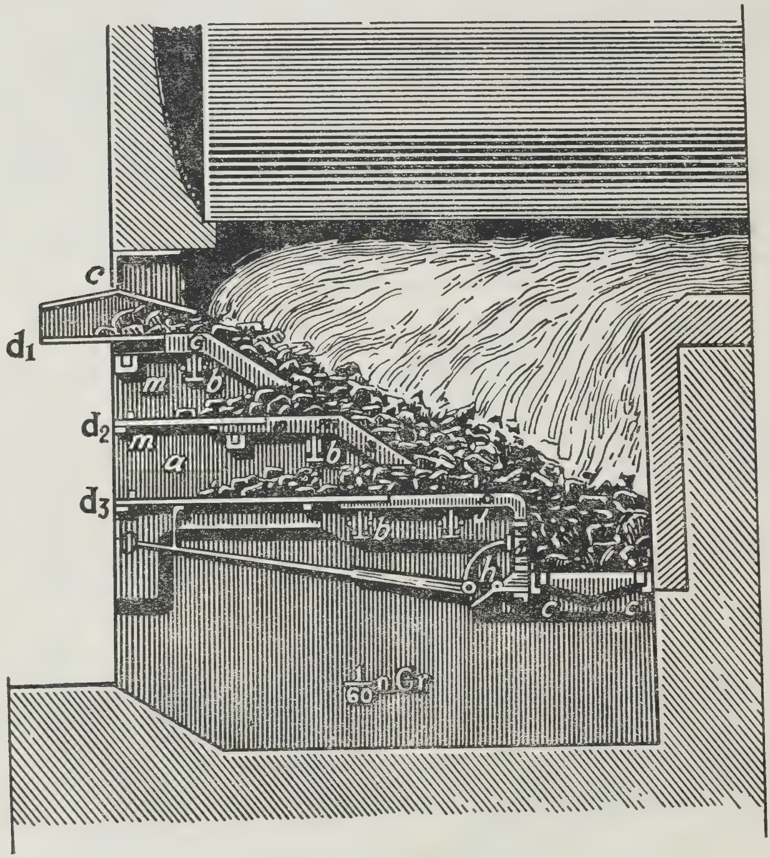
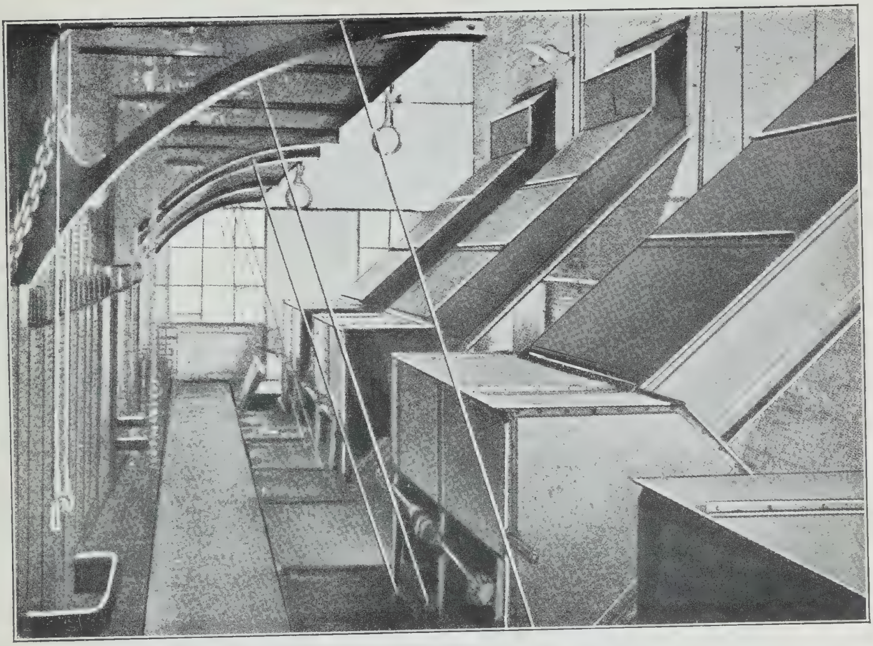


FIGURE 31. Langen step grate

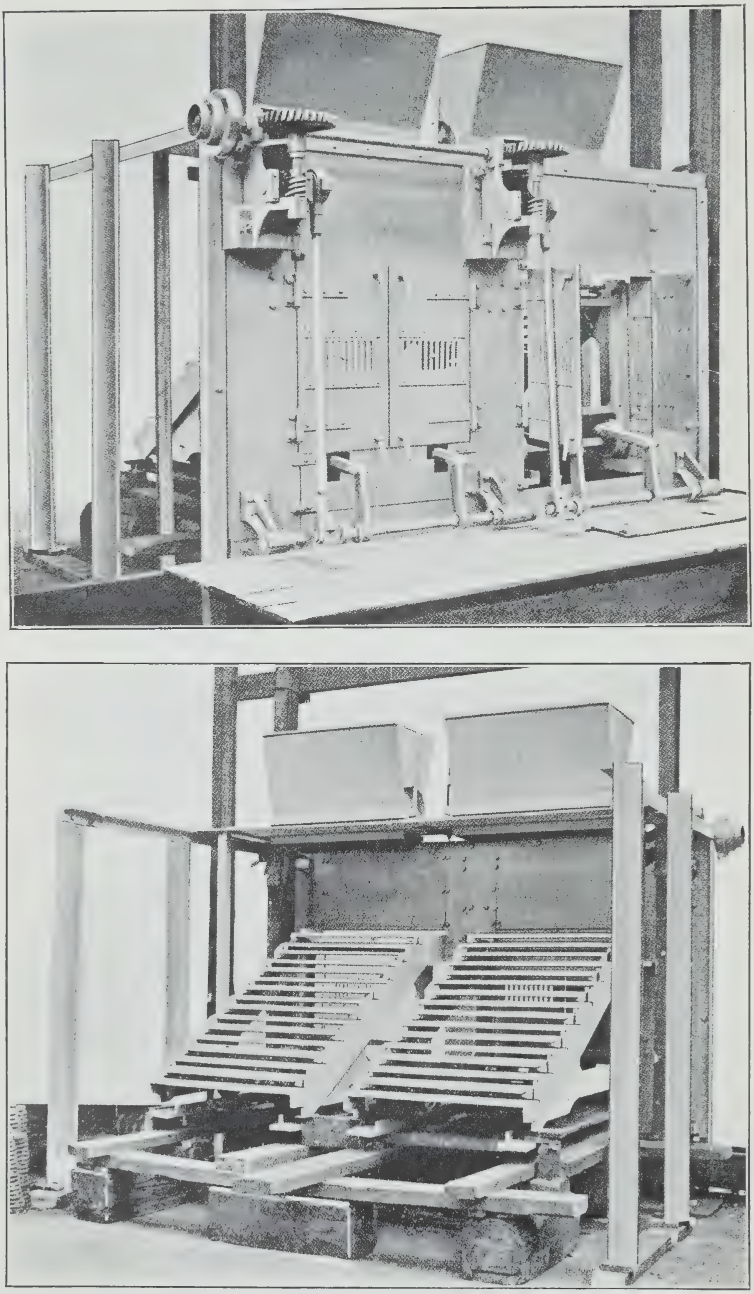
the lower end of which is an ordinary flat grate surface. As fresh fuel is fed the partly burned peat is forced inwards, and the smoke and gases from the newly charged fuel must pass through the superimposed, glowing fuel bed, where they are fully burnt by means of added air and therefore utilized for the development of heat.

[1] Handbook on the Winning and the Utilization of Peat, by A. Hausding.



Plant on Wiesmoor—boiler house, showing feeding hoppers

Air-dried peat and peat charcoal:—
(1) Large size (machine-made) briquettes
(2) Peat, broken pieces, as carbonized
(3) Peat charcoal produced



Peat-burning furnace with movable bars as applied to Babcock and Wilcox boiler

PEAT-BURNING, STEAM-POWER PLANT ON THE WIESMOOR IN OSTFRIESLAND, GERMANY[1]

The central power plant on the Wiesmoor, installed in 1910 to deliver 5,400 h.p. of electric energy, utilized air-dried peat fuel with a moisture content of 25 to 30 per cent burned on step grates.

The boiler installation comprised four water-tube boilers with a water heating-surface of 300 square metres (3,228 square feet) superheating surface of 100 square metres (1,076 square feet) and a grate area of 8 square metres (86 square feet) each.

At the time construction of this power plant was undertaken, knowledge concerning the design and methods of operating steam boilers fired with peat was very slight and a large amount of experimental work had to be conducted while the plant was in actual operation.

Facilities for storing approximately 2,500 tons of fuel under cover were provided to ensure continuous supply during the winter. Transportation from the bins to the grates of the boilers presented many difficulties, on account of the physical properties of the peat fuel. Apparatus employed in large power plants for feeding coal proved unsuitable, and entirely new contrivances had to be designed and constructed. Peat in the form of sods or even when broken into comparatively small pieces, does not easily fall by its own weight down a chute or trough. Attempts made to break or cut the peat by machinery resulted in failure, principally on account of the large amount of fines resulting, and which were practically of no value for firing purposes under the existing conditions. The difficulty, however, was overcome by alterations in some of the minor details of the apparatus. Transportation from the stacks or sheds to the bunkers was accomplished automatically by means of dumping cars, elevators and belt conveyers. The peat discharged from the last belt conveyer fell into large hoppers which filled by gravity the inclined chutes leading to the enclosed hoppers directly over the step grates of the boiler furnaces. (Plate LVI.) Every quarter of an hour or more, depending on the rate of steaming and the quality of the peat, the stoker fed the peat in measured quantities to the step grates, by operating two levers, one of which closed the hopper vertically and the other horizontally. The arrangement of the step grates was as shown in Plate LVIII.

The departure from usual boiler construction, which is of especial interest, was in the firebox and grates. Step grates inclined at 36 degrees to the horizontal were employed with great success. The grate was in two parts, each 4 square metres (43 square feet) in area. The two halves were charged alternately from the hopper placed in front of the entire grate, whereby excessive admission of air during the charging, and its rapid passage from the hopper to the grates, was prevented by the peat itself.

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[1] Peat, Lignite and Coal, by B. F. Haanel, No. 299, Mines Branch, Dept. of Mines, Canada.

The average results of several tests were as follows:—

Average steam boiler pressure	12·1 atmospheres (177·9 lbs. per sq. inch)
" temperature of steam	247·5°C (478°F)
" CO_2 content of flue gases	12·8%
" (CO_2+O) content of flue gases	19·6%
" temperature of flue gases	330°C (626° F)
" temperature of air draft	28°C (82·4° F)
" draft above grates	5·6 mm. (0·22 in.)
" draft in flue above damper	8·3 mm. (0·33 in.)
" draft in main flue	17·6 mm. (0·69 in.)
" temperature of feed water	47·7°C (117° F)
" heat in steam per kilogram	653·6 cal. (1,176 B.T. U. per lb.)

The quantity of peat burned during the tests was between 15,266 and 14,027 kilograms, and from 44,982 to 43,092 kilograms of water were evaporated, from which the average rate of evaporation = 3·01 kilograms per kilogram of peat burned, this is equivalent to an evaporation of 3·01 pounds of water per pound of peat.

The quantity of heat utilized is:

653·6 × 3·01 = 1,967 calories per kilogram = 3,541 B.T.U. per pound, which gives as the boiler efficiency, where the average heating value of the peat burned is 2,680 calories, (4,824 B.T.U. per pound) $\frac{1,967}{2,680}$ or 73·5 per cent which is far in excess of the efficiency guaranteed, viz., 65 per cent.

This excellent result, however, could not be realized in daily operation, and a figure of 65 per cent would represent the more normal efficiency. Boiler efficiencies when burning peat have, however, been considerably increased since this test was made.

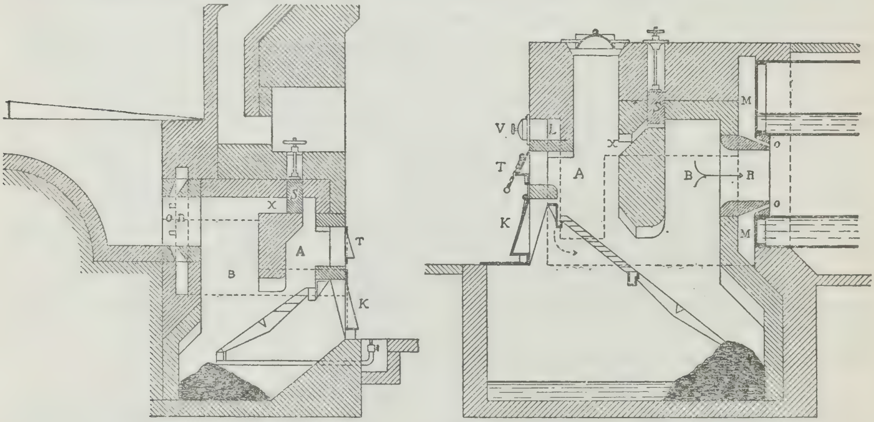

FIGURE 32. Half-gas furnace

HALF-GAS FURNACES

These furnaces have either step grates or inclined plane grates. The air admitted through the grates is not sufficient for complete combustion of the fuel, so that mostly carbon monoxide and hydrocarbons are at first formed. These are later mixed with air which is generally preheated and complete combustion without smoke is obtained.[1] Two furnaces of this type are illustrated in Figure 32.

[1] Peat and Lignite, by E. Nystrom, No. 19, Mines Branch, Dept. of Mines, Canada.

The fuel charged through the door T, or through the hopper (Figure 32) falls down on the grate, and is preheated in compartment A, where the moisture and most of the gases are driven off. The air required for the combustion of the fuel to carbon monoxide is admitted through the door K. The gases from the fuel on the lower part of the grate are mixed in compartment B with the gases previously driven off, the admittance of which is regulated by the damper S. The air necessary for complete combustion is admitted through the valve V and passes first through a channel where it is preheated, and at the same time cools the walls. The hot air passes through the holes O from the space M and is mixed with the hot gases passing through the burner R to effect complete combustion.

In furnaces of this class, evaporation of 4·2 pounds of water per pound of air-dried peat fuel is obtained. A great advantage is that peat of poor quality and peat refuse can be utilized.

PEAT POWDER

The necessity for utilizing solid fuels in the most efficient manner has led to the introduction, on a very large scale, of appliances for burning these fuels in the pulverized form.

This method not only permits of higher efficiencies to be obtained in the burning of the higher grade fuels, but also makes the lower grade fuels available for steam-raising or industrial purposes.

The advantages to be gained by burning fuels in the pulverized form are:—

(1) Increased flexibility of control of fuel and air.
(2) More complete combustion and elimination of smoke.
(3) Elimination of the troubles arising from clinkers when coal is burned on grates.
(4) Low-grade fuels may be burned efficiently.
(5) Very little excess air is required.
(6) Maximum of fuel economy is possible in many applications.
(7) Expense of supplying fuel to scattered furnaces is reduced to a minimum, since pulverized fuel can be transferred through pipes, (1) by screw conveyers, (2) in mass by means of compressed air, or (3) in suspension in a current of air.

The largest users are cement kilns and metallurgical furnaces, then steam boilers and last of all locomotives.

For utilization in pulverized form a fuel must have a certain minimum content of volatile matter in order that it may ignite freely and that combustion may be maintained. For this reason it is necessary in order to burn powdered anthracite in the most satisfactory manner to mix with it a certain percentage of bituminous coal. Gas-works coke or coke breeze contains too little volatile combustible matter to be used by itself in pulverized form.[1]

Owing to the high content of volatile combustible matter, peat can be employed to advantage in a pulverized form either alone, or mixed with powdered coal or coke, and has great possibilities not only for boiler firing but for metallurgical work and for use in cement and other kilns in which powdered coal has been successfully used.

[1] Pulverized Coal Systems in America, by Leonard C. Harvey, British Fuel Research Board, Special Report No. 1, 1919.

Peat when burned in specially constructed burners using a blast of air, acts very much like gas on account of the intimate mixture of powdered peat and air which may be obtained. The air supply can be regulated so as to closely approach that theoretically required for perfect combustion. The temperature of the flame is easily regulated, high temperatures can be obtained, and combustion is complete and smokeless. It is lighter than pulverized coal, and owing to its higher oxygen content requires a smaller supply of air for combustion than does coal. It burns with a longer flame, the ash is light and does not stick to the boiler tubes.

The chief difficulty in the way of utilization of peat in pulverized form lies in the heavy content of moisture which must be driven off before it can be properly powdered. The moisture content must be lowered to from 5 to 15 per cent by artificial drying before it is ready for pulverization.

In a small plant erected at Brockville, Ontario, in 1905, to demonstrate the Sahlstrom process for the manufacture of peat charcoal in powdered form with recovery of by-products, carbonized peat powder was successfully used as a fuel in the drier and carbonizer. The peat, air-dried to a moisture content of 50 per cent, was disintegrated and passed through a series of cylinders encased in brickwork in which it was partly carbonized. No data, however, are available as to the results obtained, and the plant, which was not on a commercial scale, was in operation only a very short time.

In 1907 Lieut. H. Ekelund commenced experimental work in the manufacture of peat powder at Bäck, Sweden, and in 1910 the plant was investigated by Captain Ernst Wallgren for the Swedish Government. As a result of several trials he reported peat powder to be an excellent fuel for use under boilers, that it had proved cheaper than soft coal for such use, and that its cost of production was very low.[1]

The raw peat, excavated from a well-drained bog and air-dried to a water content of 40 per cent, was further dried to 15 per cent in specially constructed driers. All fibrous material was screened out and used for the manufacture of moss litter, and the remaining powder when finely ground was ready for use.

The air-dried peat employed in the tests had a water content of 40·3 per cent. Average calorific value of the dry substance, 9,551 B.T.U. per pound, average effective or net calorific value of the dry substance, 8,906 B.T.U. per pound.

Total amount of peat treated	229,027 lbs.
Peat powder produced	147,906 "
Fibre produced	6,280 "

The finely ground powder had a water content of 15 per cent and an effective or net calorific value of 7,596 B.T.U. per pound.

Powder used for firing furnace was 10,863 pounds containing 9,249 pounds dry substance = 7·3 per cent of the powder produced, and 6·75 per cent of the dry substance in the air-dried peat.

Loss of dry peat substance in treatment 5,879 pounds = 4·29 per cent of the dry substance in the air-dried peat.

Total consumption of air-dried peat in the process = 6·75 + 4·29 11·04 per cent.

[1] Report on the Manufacture of Peat and Peat Powder at the Bäck Peat Bog using the Ekelund System, by Captain Ernst Wallgren—Mines Branch Bulletin No. 8, Appendix.

In a series of tests, conducted by Erik Nystrom[1] at the same plant, using peat with 50 per cent water content, 15 tons of peat powder with $12\frac{1}{2}$ per cent moisture were obtained per 24 hours with consumption of 12 per cent of the powder for the furnaces. Using peat with 40 per cent water content, the production per 24 hours was 21 tons with consumption of 9 per cent of the powder produced.

Peat powder has been used for several years as a fuel for locomotives on the Swedish State railways. Tests made in 1916 on two locomotives of the same type, peat powder with a calorific value of 7,920 B.T.U. per pound being used on one, and coal with a calorific value of 13,030 B.T.U. on the other, gave the following results:—[2]

On the locomotive fired with peat powder, the boiler efficiency obtained was 73 per cent and the firebox temperature 1670° C., while on the locomotive burning coal the boiler efficiency was 68·8 per cent and the firebox temperature 1510° C., showing that the heat value of the peat was better utilized than that of the coal. The same quantity of steam could be produced by 1·45 pounds of peat powder as from 1 pound of the coal, and with a supply of 4 tons of peat powder a freight train of 650 tons could be hauled 62 miles, and a passenger train of 300 tons, 81 miles.

Two large peat-powder factories were set up during the war at Vislanda and Vako. The latter has been shut down since 1919, but the Vislanda factory supplying fuel to the Swedish State railways is still in operation.[3]

Peat powder is also reported to have been successfully used in Swedish iron and steel-melting furnaces.

The principal difficulty in the way of production of peat powder on an economic basis, viz., the very high water content of raw peat, has been already mentioned. Preliminary air-drying of the raw peat to a water content of 40 per cent or lower must be effected. A large amount of powder and heat are required for further drying and grinding the peat, and a large proportion of the fibre and wood in the peat must be removed to facilitate grinding. Until such time as the manufacture of air-dried machine-peat fuel is well established, it is improbable that the manufacture of peat powder can be undertaken in Canada with favourable economic results.

Eventually, however, the extensive peat deposits in proximity to the Canadian National railway in northern Ontario and Quebec, may become a valuable source of auxiliary fuel supply for locomotives.

The use of fuel in pulverized form not only increases the effective values but permits the efficient utilization for various purposes of lower grade fuels. The problem of economic use of low-grade fuels has become of increasing importance, and, therefore, much attention has, in recent years, been directed to the use of powdered fuels.

This has been particularly the case in the United States where the annual consumption of pulverized fuel is already in excess of 10,000,000 tons per annum.

Since the application of this method of combustion would appear to have an important bearing on the utilization of such a low-grade fuel as peat, a brief discussion of the subject is included in this report.

[1] Peat Powder, by Erik Nystrom, Mines Branch Bulletin No. 8, Appendix.
[2] Engineering (1916) Vol. 102, p. 387.
[3] The Production of Air-dried Peat, First Section, Report of the British Fuel Research Board for the years 1922, 1923.

AIR-DRIED PEAT AS LOCOMOTIVE FUEL

Attempts to use air-dried peat as a fuel in railway locomotives were made as long ago as 1866, when peat fuel made at Bulstrode, Que., by the Hodges' process was burned on engines of the Grand Trunk Railway Company.

In a test recorded by the Montreal Gazette (Dec. 1, 1866), an engine hauling a train of 18 cars weighing 332 tons, consumed 7,450 pounds of air-dried peat in a run of 112 miles, being at a rate of 66½ pounds per mile. As a result of many tests on the wood-burning engines employed at that time a contract extending over five years was made by which the company agreed to take 100 tons per day for the first season, and 300 tons per day during the four succeeding seasons. Owing to defective equipment and methods of manufacture, fuel could not be supplied to fill this contract. In the effort to do so quantities of imperfectly dried peat were delivered, which proved unsatisfactory and caused abandonment of the undertaking.

Experiments in the use of peat on railroads were continued for many years in Germany; but owing to the bulkiness of the peat fuel, the larger amounts of it required than of coal, the additional labour needed owing to more frequent firing, and other difficulties of an economic nature, efforts along this line were gradually given up.

CHAPTER XI

CARBONIZATION OF PEAT

The objectives sought in carbonizing fuels high in volatile matter are: increase of carbon content, modification of physical structure, and recovery of by-products. With peat, an increase in carbon content is accompanied by a material increase in the calorific value. Peat, whether manufactured according to the air-dried machine-peat process, simply hand dug and air-dried without other treatment, or briquetted after being prepared according to either of the above methods, is unsuitable for many industrial purposes and must be submitted to heat treatment in order to extend its field of usefulness. Such heat treatment is effected by carbonizing in a retort or oven in the absence of air. The products obtained by carbonization are: uncondensable gases; pyroligneous acid liquor, containing ammonium acetate; methyl alcohol compounds; tar oils; and peat coke or charcoal. When peat is carbonized in a closed retort these products can be recovered; but when carbonization is effected by direct heat obtained from the combustion of gases, as is the case when peat is carbonized in heaps similar to the older method employed for carbonizing wood for the manufacture of charcoal, the coke or charcoal only is recovered.

Carbonization may be effected by means of direct heat, or radiated or conducted heat.

Carbonization by direct heat is effected when a fuel is coked in heaps. The heat required is obtained from the combustion of the gases evolved from the volatile content of the fuel and the combustion of a small amount of the carbon content. The heat thus generated is applied within the heap of fuel and the heap of fuel is said to be internally heated. When, however, the fuel is coked in closed retorts and ovens, which are externally heated, the carbonization of the fuel is said to be effected by radiated or conducted heat.

METHODS EMPLOYED FOR CARBONIZING PEAT

Carbonization in Heaps or Meilers

When peat is carbonized according to this method it is usually cut into rectangular blocks, 14 to 15 inches in length by 6 inches in thickness, and these are piled in heaps 6 to 8 feet in diameter and 4 feet high. Each heap contains from 5,000 to 6,000 blocks. When building the heap care must be taken to avoid air spaces.

The construction and manipulation of the piles are the same as for the bee-hive carbonization of wood, but the supervision and the carrying out of the process are much more difficult for peat than for wood. Owing to the many interstices which are unavoidably produced in spite of the greatest care in building the pile, and to uneven sinking of the various layers, the peat pile settles in a very irregular manner, producing clefts and fissures in the covering.

5664—15½

Peat charcoal is difficult to quench and cannot, like wood charcoal, be quenched with water, since the water either runs off without producing any effect or is converted into steam, which breaks and crumbles the charcoal—which is always friable. The usual method employed for quenching the glowing charcoal is to cover the pile with a compact coating of wet clay, in such a manner that all entry of air is prevented. The cooling process requires two days, and the carbonization, including the burning and cooling of a pile, lasts from eight to twelve days or more. The output of charcoal amounts to 28 to 35 per cent, averaging 30 per cent by weight, but in the case of good dry machine-peat it may be as high as 40 per cent.

Carbonization in Clamps

For the construction of ricks or clamps employed in Saxony[1] the ground was levelled and covered with sand over a rectangular area about 50 feet in length by 5 or 6 feet in width. In the centre of this space a hollow was formed and channels, constructed to prevent loss of the by-products by percolation, were provided to conduct the tar and ammoniacal liquor to a tank near the rick. Stakes were fixed about 10 feet apart in the longitudinal channel, and the rick was built up to a height of about 4 feet, leaving cross air-channels in line with the stakes which were then drawn out and the rick covered in a manner similar to that of the meilers. A fire-place was provided in the central channel by means of which the rick was ignited.

The charcoal prepared was of good quality and was used for metallurgical purposes.

Born's "Mound-Carbonizing Process"

This process[2] was based on the discovery that "half-wet" crumbs or even sods of lowland peat, when piled in heaps 25 feet in height became very hot, caked together and contracted a good deal; that the water content was uniformly distributed and much of it was evaporated and that the product resulting after nine to twelve months was a much drier, black granular mass. Born attributed this phenomenon to fermentation of the peat, which resulted in the bursting of the cells by the heat produced. The peat mass thus fell into a powder which, as humification proceeded, was caked firmly together by the pressure of the mound. According to his suggestions the partly dried peat sods piled into mounds would, in from one to two years, contract to a quarter of their original volume, and have a calorific value equal to that of brown coal. This method he stated would, without further treatment, produce a uniformly dense fuel sufficiently dry and suitable for gasification or for direct firing.

Since this process, although to a great extent independent of weather conditions, would be very slow, Heine[3] proposed to use peat dehydrated by pressure to 60 per cent moisture. This was to be piled in a mound into which ozonized air would be admitted through tubes. It was claimed that in this manner owing to the more rapid absorption of oxygen, a considerable amount of drying could be effected within a few weeks without spontaneous ignition occurring. Neither of the processes has so far been carried out with commercial success.

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[1] Peat, its Use and Manufacture, by Bjorling and Gissing.
[2] Handbook on the Winning and the Utilization of Peat, by A. Hausding.
[3] Op. cit.

Carbonization in Ovens

In an effort to overcome the difficulties of ordinary carbonization in heaps, bee-hive ovens were introduced during the last century. These generally had walls of stonework or cast iron, and were cylindrical in form with an opening in the roof for the charging of fresh peat, and another at the base for removing the charcoal. Although most of the evils encountered in carbonization in piles were avoided by working with these ovens, the yield was not appreciably improved. Owing to irregular contraction of the peat, and consequent slipping of the upper layers of fresh peat, the charcoal below was injuriously affected, resulting in production of many small pieces and much waste and dust. In order to overcome this defect, ovens were built in which the peat burned from above downwards. Hahnemann's oven[1] is one of the oldest furnaces of this type. In Wagenmann's[1] oven the shaft tapers from above downwards according to the degree to which the peat contracts on carbonization. From raw material of similar quality the yield of large pieces of charcoal from these furnaces was far greater than that from piles or ovens in which the direction of the draught was upwards. In order to reduce the quantity of the peat which had to be burned to produce the heat required for carbonizing, Dr. Schenck generated gases from waste or inferior peat in a special retort, and led these gases through the cover of Wagenmann's oven into the carbonizing chamber where they were burned. This resulted in a better yield of charcoal.

Weber's[2] carbonizing oven was based on the same principles, and with it a yield of 50 per cent by weight and 75 per cent by volume was obtained. At Staltach a very strong and compact charcoal with an apparent specific gravity of 0·30, which could be used in cupola furnaces, was produced in these ovens from dense moulded peat.

Carbonization in Muffles by Heat Radiated or Conducted[3]

The heat for carbonizing, according to this method, was obtained from the combustion of gases from a gas producer. The hot or burning gases were conducted through the walls of iron muffles or retorts from which the air was completely excluded. The objectives aimed at were utilization of the less valuable fuel for producing the heat required for carbonization, increase of the yield of charcoal by carbonizing in the total absence of air, and the more efficient collection of by-products. The results did not, however, altogether correspond to expectations, as the consumption of fuel was relatively high (33 per cent of the peat to be carbonized) and the output of charcoal both as regards quality and quantity, was not appreciably superior to that obtained by carbonization in piles. Moreover, the gain due to the utilization of the by-products did not correspond to the expense incurred in their further treatment.

Jungst's and Lottmann's ovens [3] were of the above type. The Jungst ovens employed at the Alexis works at Lingen are reported to have had a weekly output of 1,150 kilograms of charcoal per oven with a fuel consumption equivalent to 25 to 30 per cent of the peat treated. The yield of charcoal is said to have been 40 per cent by weight for light peat and 60 per cent for dredged peat.

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[1] Peat and Lignite, by E. Nystrom, No. 19, Mines Branch, Dept. of Mines, Canada.
[2] Handbook on the Winning and Utilization of Peat, by A. Hausding.
[3] Op. cit.

Fifteen Lottmann ovens were in regular operation at the Josefsthal Iron Works in 1860, but their operation did not prove to be economical, since with a fuel consumption of 45 per cent, the yield of charcoal was only between 30 and 40 per cent.

Carbonizing ovens were constructed with wrought iron muffles in a peat charcoal factory erected for the Salzburg Peat Bog Utilization Company by Dr. G. Thenius.[1] In shape and setting these ovens were similar to the muffles and retorts employed in coal-gas works. The plant proved to be uneconomical and was soon abandoned.

More recently attempts to carbonize peat have been revived, and heralded as a "new solution of the peat problem." Numerous suggestions for improving processes were proposed, and some of these were incorporated in the design of ovens which were constructed and put into operation on a large scale, but most of them after a short time were given up as failures.

H. Ekelund of Jönköping, Sweden, proposed to carbonize hand-cut peat with 60 per cent moisture in special ovens provided with a fore-drying chamber.[2] The claim was made for his process that peat with 60 per cent moisture could be carbonized with one-tenth of the fuel required for the carbonization of the same quantity of peat with 30 per cent moisture in a muffle. The estimated cost of the single-oven plant to produce 8,000 metric tons of dense, fresh charcoal per annum was 16,500 kroner (about $4,500). Expectations were not realized and the experimental factory was soon closed down.

According to Gumbert and Loe's process,[3] freshly slaked lime was added to the dried peat, and the mixture carbonized with recovery of by-products. The residual charcoal was briquetted. Hausding says of this process: "It is evident that this cannot be done with commercial success. Considering the prevalent prices for the more common fuels, as well as the decrease in weight due to carbonization, the price of unit weight of the residual peat charcoal is much too high in comparison with the increase in the calorific power due to the carbonization."

Ziegler's Process [4]

Among the more notable attempts to carbonize peat, is the process devised by Ziegler, a civil engineer of Berlin, which is based on a modification of an oven successfully employed for the gasification of brown coal. The process was first tried at Oldenburg in 1894-1897. Repeated alterations and improvements were made and operations continued until 1913, and although favourable reports were made, no commercial success was achieved. The Oldenburg factory which was equipped with five ovens, for operation on a large scale, produced a good marketable charcoal, and was claimed to show a satisfactory profit. Similar factories were erected on the strength of these claims at Redkino, Russia; Beurenburg, Bavaria; and other places; none of which, however, came up to expectations.

Ziegler, like Ekelund, sought to make the process independent of the weather by using partly dried raw peat. Special stress was laid on the recovery of by-products to reduce the cost of the peat charcoal.

[1] Handbook on the Winning and Utilization of Peat, by A. Hausding.
[2] Op. cit.
[3] Op. cit.
[4] Op. cit.

The process was continuous and utilized to the fullest extent all waste heat from the carbonizers and furnaces. The heat set free during the carbonization was used for concentrating the by-products, and the waste combustion gases from the furnace employed to heat the ovens were mixed with air and used to dry the peat.

In addition to peat charcoal a product, which may be termed semi-charcoal, could be produced in these ovens without modifying the plant by passing the peat more rapidly through the ovens. This was an incompletely carbonized product from which only small quantities of tar and gases had been removed. It resembled, and was almost as strong and compact as peat charcoal.

The peat charcoal was obtained in large pieces, was porous like coke, but rang hard, and unlike wood charcoal withstood pressure as well as coke.

In carbonizing air-dried peat containing 25 to 30 per cent moisture the Ziegler ovens produced on an average:—

—	In making peat charcoal	In making semi-charcoal
	%	%
Peat charcoal or semi-charcoal	35	50
Peat tar	4	2
Tar and water	40	36
Gases	21	12
	100	100

The analysis of the peat charcoal product obtained compared with wood charcoal was as follows:—

—	Peat charcoal	Peat semi-charcoal	Wood charcoal
	%	%	%
Carbon	84·23	73·50	85·18
Hydrogen	1·93	3·59	2·88
Nitrogen	1·49	....	....
Oxygen	6·28	14·41	3·44
Sulphur	....	0·20	....
Ash	3·09	2·50	2·46
Moisture	4·47	4·34	6·04
	100·00	100·00	100·00
Calorific value, calories	7,042	6,776	7,670
B.T.U	12,670	12,190	13,800

In the carbonization of moist peat a twofold loss occurs:—

(1) Waste of fuel for evaporation of the moisture.

(2) Loss of carbon due to the water vapour reacting with carbon in passing over the glowing charcoal and forming carbon monoxide and liberating hydrogen.

Hence, only well air-dried peat is suitable for carbonization.

To compete with wood charcoal and coke the peat charcoal produced must be in large pieces, as dense and strong as possible, and with a high calorific value.

The denser the raw peat is, the denser the charcoal obtained from it will be. Good strong charcoal, suitable for metallurgical work, can only be obtained from machine-peat which has been thoroughly macerated in the process of manufacture.

Peat briquettes or pressed peat formed by strong mechanical pressure, are unsuitable for carbonization since the cohesion between the particles is completely destroyed by the action of heat and this results in the formation of small pieces of a very loose and friable charcoal.

Bamme's Process [1]

Bamme's oven differed somewhat from Ziegler's. It was a chamber oven consisting of a number of compartments lying beside one another, with a sloping base, and provided with heating flues underneath as well as in its sides. Peat containing 25 to 30 per cent moisture was carbonized with recovery of charcoal and by-products. Plants were erected at Augustfehn in Oldenburg, and Stickhausen in East Friesland, but were not commercially successful.

Effect of Ash

The percentage of the ash in the peat to be carbonized has a great effect on the calorific value of the charcoal produced. As the yield of charcoal is only 30 to 40 per cent, and it contains the total ash of the peat, the percentage of ash in the charcoal will be from $2\frac{1}{2}$ to $3\frac{1}{2}$ times as high as that of the peat from which it is produced. Consequently only peat low in ash content is suitable for carbonization. Where the ash content of the peat is as high as 10 per cent, the percentage of carbon in the charcoal may be as low as 60, depending on the amount of oxygen, hydrogen, and nitrogen in the raw peat.

A prime essential for carbonization is a dry machine-peat low in ash and as dense as possible.

The general freedom of peat from sulphur and phosphorus renders the utilization of peat charcoal advantageous for metallurgical operations. The nature of the ash facilitates the formation of an easily fusible slag. Where peat charcoal is employed for smelting iron, and so far as its advantageous influence on the iron is concerned, the ash is more nearly related to that of wood charcoal than to that of coke. This property has made peat charcoal highly esteemed for certain purposes.

[1] Handbook on the Winning and the Utilization of Peat, by A. Hausding.

CARBONIZATION AND BRIQUETTING FOR THE MANUFACTURE OF DOMESTIC FUEL

Carbonizing and coking processes not only involve very heavy capital expenditures and complicated and costly operations, but owing to the high volatile content of peat the resultant fuel production is very small in proportion to the quantity of raw material handled.

The devising of a process which would economically remove the water content of the peat by pressure, carbonize the dewatered substance and briquette the carbonized residue, has been frequently attempted under the belief that such a process would enable the manufacture of peat to be conducted continuously throughout the year regardless of weather conditions.

Schoening and Fritz Process [1]

A plant employing this process was operated near Stettin, Germany. Its capacity was over 3 tons of briquettes per hour. A small plant was also operated at Halmsee, Germany.

According to this process disintegrated peat is passed through a series of three horizontal retorts heated to a maximum temperature of 250° C. in 30 minutes, and partial carbonization results. The hot semi-char is conveyed to the dies of a heavy hydraulic press, the plungers of which are heated to 200° C., and is submitted for 12 seconds to a sustained pressure of 300 atmospheres. The briquettes produced were heavy and strong, and burned with a long flame.

Stillman says: "It is very evident that unless fuel made in this manner can command a substantial premium over coal prices, it will not pay to install such a factory in the United States." [2]

CARBONIZATION EXPERIMENTS AT FUEL TESTING STATION

Small-scale Laboratory Experiments

A series of small-scale carbonization experiments on samples of air-dried peat from the Alfred bog was carried out in 1920 at the Fuel Testing Station of the Mines Branch, Ottawa, by Edgar Stansfield and J. H. H. Nicolls.[3]

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[1] Peat and Lignite, by E. Nystrom, No. 19, Mines Branch, Dept. of Mines, Canada.
[2] Briquetting, by A. Stillman.
[3] Carbonization of Peat, by E. Stansfield and J. H. H. Nicolls, Mines Branch, Dept. of Mines, Canada, No. 577—Investigations in 1920.

The samples which had a moisture content of 25 per cent consisted of small cylindrical briquettes of finely ground peat moulded in a hand-press. The results of the experiments are shown graphically in Figure 33, and Table XXIII which is derived from the rounded curves in the diagram indicates the results obtained from the carbonization of dry peat.

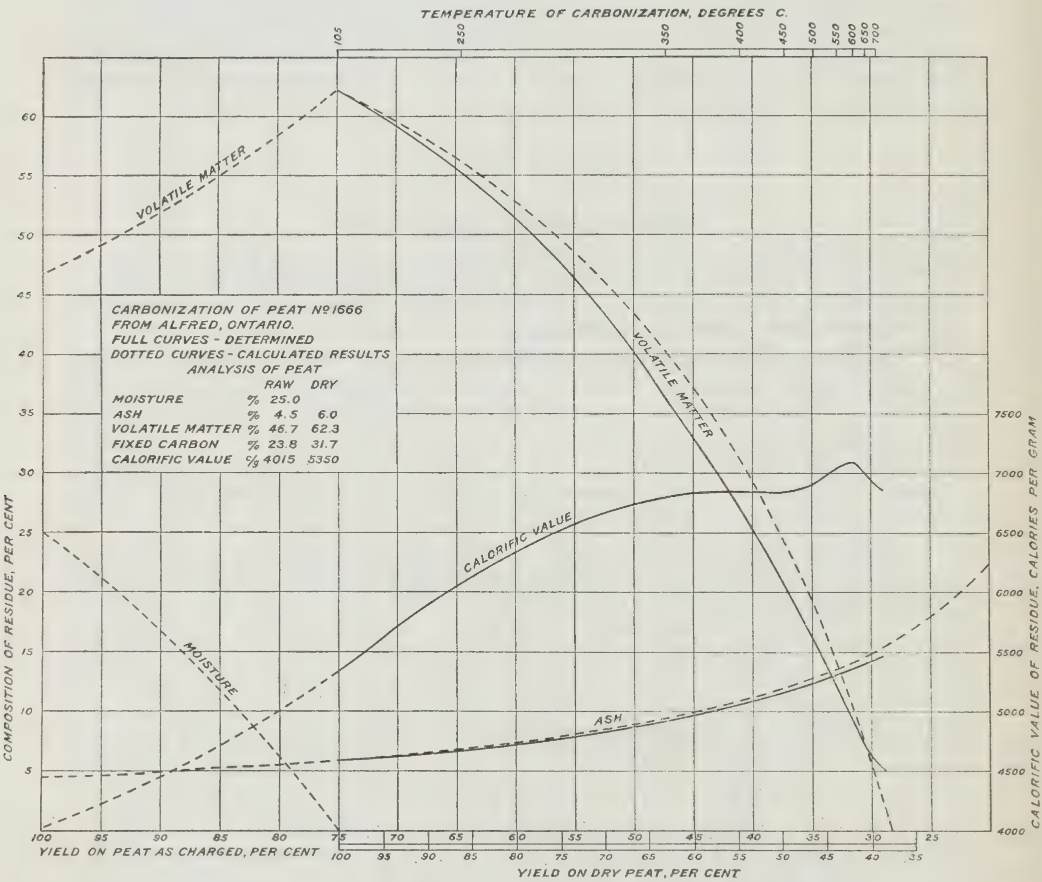

Figure 33. Results of carbonization experiments

TABLE XXIII

Small-scale Carbonization Tests on Dried Peat

Temperature of carbonization, degrees C.	Yield of residue %	Analysis of residue			
		Calorific value calories per gramme	Ash %	Volatile matter %	Fixed carbon %
105°	100·0	5350	6·0	62·3	31·7
250°	86·0	6090	6·7	55·1	38·2
280°	77·8	6400	7·3	49·9	42·8
350°	63·3	6800	9·2	36·3	54·5
400°	54·9	6840	10·7	26·7	62·6
450°	49·7	6850	11·6	20·0	68·4
500°	46·3	6910	12·5	15·8	71·7
550°	44·0	7030	13·1	12·3	74·6
600°	42·1	7090	13·6	9·7	76·7
650°	40·6	6990	14·0	7·0	79·0
700°	39·3	6900	14·4	5·6	80·0

CARBONIZATION RUNS IN HARDWOOD DISTILLATION OVENS

In August, 1922, commercial-size carbonization experiments were made on a carload of air-dried machine-peat. These tests were carried out in co-operation with the Standard Chemical Company of Canada in their plant situated at Longford, Ontario, and were supervised by R. E. Gilmore, chief engineering chemist of the Fuel Testing Division of the Mines Branch, Ottawa. The ovens used were of standard size and the carbonization process was the same as that used in the regular hardwood distillation practice.

The purpose of these experiments was twofold. First: to determine the feasibility of carbonizing Canadian air-dried peat to obtain charcoal and other chemicals by the same destructive distillation process as is used for hardwoods. Second: to determine to what extent peat may be considered as a substitute for hardwood in the manufacture of charcoal and chemical products. The scope of the tests was, therefore, limited to the carbonization process used in the hardwood distillation industry, which is a low temperature, destructive distillation process in which the temperature is controlled in the neighbourhood of 300°C. (572° F.).

Products obtainable from peat other than charcoal are peat tar oils; pyroligneous liquor containing ammonium acetate; methyl (alcohol) spirits; and gas. The objective was, as with hardwood, to obtain as large a yield as possible of liquid products, viz.: methyl spirits and light oils. The charcoal yield, as a result of this procedure is also high, compared with other carbonization processes and is of a good quality. The yield of gas and ammonia obtainable will necessarily be comparatively low.

Under the authorship of R. E. Gilmore and Harold Kohl a full report of these large-scale experiments is given in the Summary Report on Mines Branch Investigations for 1922, pages 194 to 209. The oven and carbonization process are fully described and the details of the tests are given. The essential points, comparisons made, and the summary conclusions will, however, be included here.

The carload of air-dried peat used in these tests was supplied by the Peat Committee from the bog at Alfred, Ontario, the analysis of which was as follows:—

Proximate analysis		As Rec'd basis	Dry basis
Moisture	%	25·6	
Ash	"	4·6	6·2
Volatile matter	"	48·5	65·3
Fixed carbon	"	21·3	28·5
Sulphur	"	0·25	0·33
Nitrogen	"		1·5
Calorific Value— B.T.U. per pound		7,040	9,470

The peat consisted of irregular lumps varying in size from 2 to 3 inches in diameter to pieces as large as an ordinary brick (Plate LVII). The process of manufacture at the bog consisted of macerating the wet peat containing about 90 per cent water and then, after spreading on the ground and cutting into the required sizes, allowing it to dry in the open air. The air-dried peat on arrival at Longford was not so good as that sold as household fuel. It was loaded into the buggies from a pile on the ground by means of a steam shovel and in this way differed from hardwood which must be loaded by hand.

Two experimental runs were made on August 7 to 10 inclusive. In the first run three buggies containing slightly over 4 tons each were charged into the oven, and for the second, each of the three buggies used contained about $3\frac{1}{3}$ tons.

Run No. 1—

Weight of peat charged..............25,868 lbs.—12·9 tons
Equivalent of dry peat..............19,248 lbs. — 9·7 tons
Time and date charged into oven....8 a.m., August 7
Time and date drawn from oven.....7 a.m., August 9
Actual duration of run...............36 hours
Average temperature of exit gases....560°F (293°C).
Fuel used under the oven............1 load of wood waste—sawdust and wood chips (i.e., other than peat gas) equivalent to about $1\frac{1}{4}$ tons of soft coal.
Yield of peat charcoal...............9,728 lbs. (15 per cent breeze)
Total oven liquor measured.........1,144 Imp. gallons
Tar oils.........................208 "
Aqueous liquor..................936 "
Methyl (alcohol) spirits in liquor....1·10 c.c. per 100 c.c.
Ammonia (NH_3) in liquor...........0·45 grm. per 100 c.c.

Run No. 2.—

Weight of peat charged..............20,408 lbs.—10·2 tons
Equivalent to dry peat ....15,183 lbs.— 7·6 tons
Time and date charged into oven....8 a.m., August 9.
Time and date drawn from oven ....2 p.m., August 10.
Average temperature of exit gases....570°F. (309°C).
Fuel used under the oven............2,654 lbs. of slack coal (soft).
Yield of peat charcoal ....7,868 lbs. (15 per cent breeze).
Total oven liquor as measured.......852 Imp. gallons
Tar oils ....124 "
Aqueous liquor..................728 "
Methyl (alcohol) spirits in liquor....1·30 c.c per 100 c.c.
Ammonia (NH_3) in liquor ....0·45 grm. per 100 c.c.

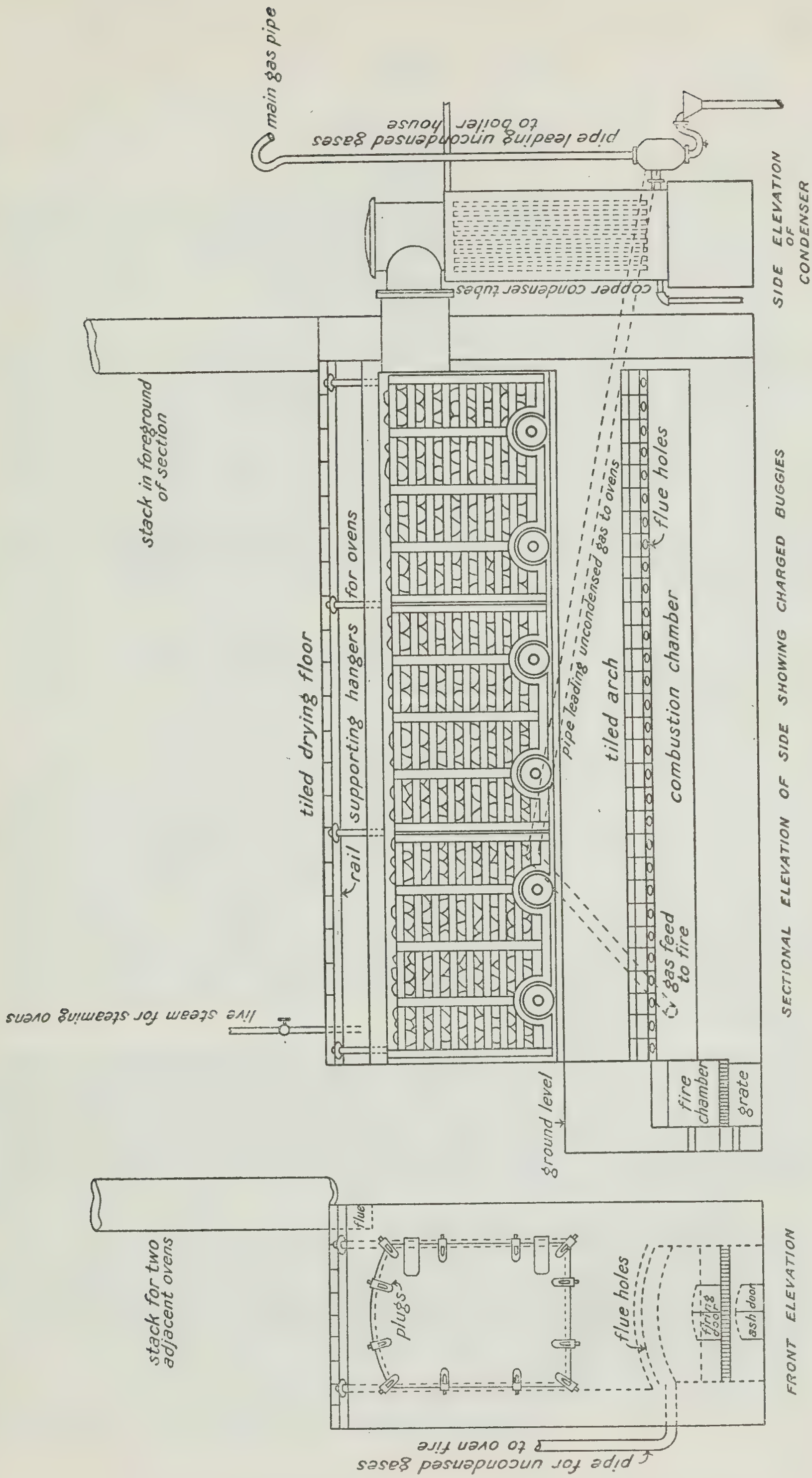

FIGURE 34. Carbonization oven with condenser

Operation Remarks

In the first run the buggies used were loaded nearly to the top of the side bars. The same buggies loaded to this level with cordwood held two cords each, equivalent to, roughly, 2 tons per cord. It was, therefore, noticed that peat of 25 per cent moisture content had practically the same bulk as hardwood of equal moisture content.

In experiments previously carried out on peat in the laboratory it had been necessary to allow the condenser water to warm up, to prevent the thick tar oils from clogging the (spiral) condenser tube. At the same time it was necessary to keep the water, especially at the bottom of the condenser, cool enough to condense the low-boiling alcohol constituents. Although precautions were taken, a little difficulty was experienced during the first half of run No. 1. During the latter part of this run, however, and in run No. 2, the flow of oven liquor was fairly uniform. In regular practice, using peat, a combination of a warm condenser followed by a cold condenser or scrubber would overcome any difficulty of condensing both the thick tar and the low-boiling liquids.

Care was taken to look for indications of exothermic reaction. With hardwoods with moisture contents of about 25 per cent and lower, as previously remarked, somewhat sudden increases of liquor and gas are noticed at about the seventh to the ninth hour and if the fire under the oven is not checked and controlled at this point, or earlier, the temperature within the oven rises to too high a point and as a consequence the rate of reaction increases to such an extent that a serious loss in valuable liquid products is likely to result. As, however, the moisture content of the hardwoods ranges higher than, say, 25 per cent, the exothermic reaction is not so noticeable. For the high moisture hardwoods constant external heat is required to carry on and complete the reaction. During the two experimental runs with peat no appreciable exothermic reaction was noticeable. Whether this was due to too high a moisture content or was normal to peat with this moisture content is difficult to say. The shape of the curves in the constituents of the gas was, however, the same as those on a typical run using hardwood.

The comparative quantities of tar oils and aqueous distillate in the oven liquor were observed every hour from samples taken in a graduated glass cylinder. After standing, a more or less complete separation took place and readings were then taken. The total oven liquor was pumped to a tank and measured. After settling, measurements were made of the total separated clean liquor and settled tar.

Figure 34 is a diagrammatic sketch of the carbonizing oven and Figure 35 is a flow-sheet of the process.

The crude, factory operations follow closely those used for hardwoods, but the laboratory refining of the crude peat products is slightly different from that for hardwood.

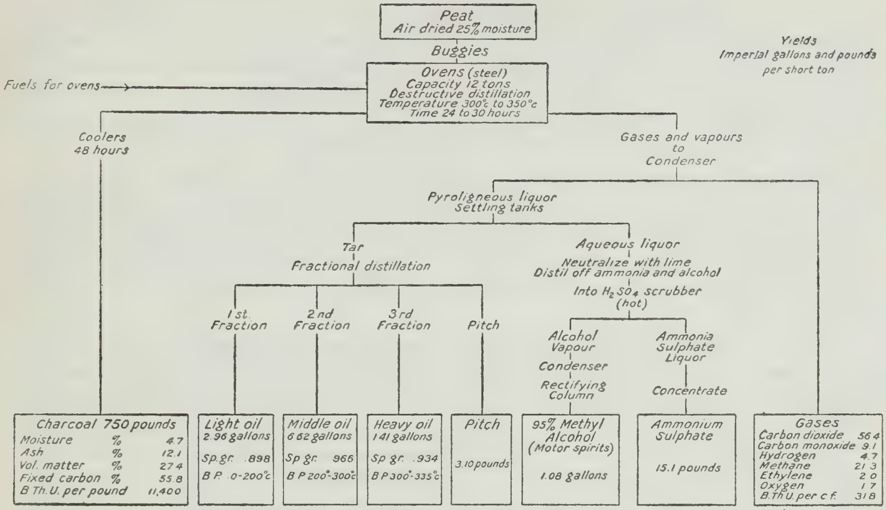

Figure 35. Flow-sheet, destructive distillation of peat

Examination of Products

The peat charcoal produced was passed over a square $\frac{3}{8}$-inch mesh screen, and what passed through was termed "breeze." The percentage of screened lumps and breeze was roughly 85 and 15, respectively. Bag samples of each were taken for analysis. Barrel-size samples of both the aqueous distillate and settled tar were sent to the laboratory in Ottawa for analyses and reserve samples. The aqueous distillate which may be termed "peat pyroligneous acid" was a clear straw colour and the tar oils were of a consistency that flowed readily when poured from one vessel to another.

The pyroligneous acid from peat differed from that from hardwood in that the former contained an appreciable amount of ammonia and amine compounds. On the other hand the acid content of the peat liquor was small as compared with that from hardwood. In ordinary hardwood pyroligneous acid practice the liquor is neutralized with lime before distilling off the crude alcohol. The residue on evaporation would yield brown acetate of lime.

For the recovery of the alcohol product from the peat liquor, two different methods are feasible. When the settled liquor is over-neutralized with lime and distilled, similar to the practice for liquor from hardwoods, the ammonia compounds are liberated and come over with the alcohol vapours. With this method nauseous vapours are given off which are a source of annoyance to those working in the laboratory. For this reason and also to permit the recovery of the alcohol free from amine compounds, the peat liquor was distilled from acid solution.

After adding a small amount of sulphuric acid the peat liquor was distilled in a special glass bead Hempel column fitted with a Soxhlet ball reflux condenser as dephlegmator to obtain an alcohol distillate, leaving behind a weak liquor containing a mixture of ammonium acetate and ammonium sulphate. After breaking down with water and neutralizing with alkali, the crude alcohol was again rectified to obtain an alcohol solution as high as 90 per cent volume hydrometer reading.

The ammonia content of the peat liquor was obtained by over-neutralizing a fresh portion of the original liquor and distilling into a standard acid solution in the usual way. A fresh sample was also taken for the determination of the volatile acids. After adding excess sulphuric acid these were distilled off in a Kjeldahl apparatus and titrated to be expressed as acetic acid.

Another method, which no doubt would be more practical, to obtain an alcohol product to be used for motor spirits, would be to distil or rectify the liquor after over-neutralizing with lime, through a sulphuric acid scrubber, to thus recover the ammonia early in the refining process and to obtain the alcohol free from ammonia. The alcohol solution could then be concentrated by rectification in the usual way. After the removal of the ammonia and alcohol, the weak calcium acetate liquor containing tar and other impurities could be further refined for acetate value or discarded. This is the method outlined in the flow-sheet (Figure 35).

The tar oils after first being washed with water to remove all water soluble alcohol products, and then allowed to settle, were examined as to density and distillation range. Cuts were made according to the American practice into light, medium, and heavy oils and pitch.

Peat Gases by Low Temperature Carbonization

The yield of oven gas during the commercial-scale run was not obtained. Some idea of this yield is, however, available from the laboratory-scale runs referred to in the next paragraph. During the runs at Longford, samples of the uncondensed gas were taken at intervals of two hours. Table XXIV gives the analyses of these samples taken during No. 2 run.

As referred to in the early part of this report laboratory-scale tests had previously been carried out. These tests were made on 12 to 13-pound samples of air-dried peat averaging 12·5 per cent moisture and were conducted under conditions similar to laboratory efficiency experiments on different hardwoods. Two runs only, on peat were made and while they were not entirely satisfactory, the results are of interest as they permit a comparison with those obtained on the commercial scale. In Table XXV the laboratory results have been recalculated for air-dried peat on a 25 per cent moisture basis. For the sake of comparison, or rather contrast, the average yield per ton of hardwood (4,000 pounds per cord) has been added.

TABLE XXIV

Composition of the Gases—Run No. 2

Samples taken at intervals of 2 hours

Sample No.	1	2	3	4	5	6	7	8	9	10	11	12
Time in hours	6th	8th	10th	12th	14th	16th	18th	21st	23rd	25th	27th	30th
Carbon dioxide %	70·1	78·0	75·2	74·0	62·2	56·6	57·0	48·8	49·0	44·2	37·8	36·4
Carbon monoxide %	6·2	6·3	4·0	4·2	11·8	12·1	12·4	19·5	10·6	6·0	5·5	4·1
Hydrogen %	......	......	1·1	......	......	......	0·1	......	......	10·4	13·0	24·5
Methane %	6·7	8·9	9·1	12·0	18·4	21·2	23·4	24·2	31·6	31·2	37·7	30·5
Ethylene %	0·2	......	1·6	2·6	1·8	4·1	2·6	2·5	2·9	2·7	2·4	2·2
Oxygen %	3·4	1·5	2·1	2·3	1·3	1·2	1·2	1·2	1·2	1·5	1·8	0·7
Nitrogen %	13·4	5·3	6·9	4·9	4·5	4·8	5·3	3·5	4·7	4·0	2·8	1·6
Calorific value (calc'd)	90	109	133	175	240	316	316	316	344	396	408	434
Density (calc'd) air=1	1·32	1·37	1·32	1·29	1·25	1·20	1·21	1·15	1·12	0·97	0·91	0·84

TABLE XXV

Comparison of Yields of Commercial Products per Ton (2,000 lb.) of Air-dried Peat and Hardwood

Commercial products		Air-dried peat		Hardwood
		Average of two laboratory runs	Average of two commercial runs	Commercial yield per ½ cord
Charcoal	lb.	700	756	540
Oven liquor	Imp. gals.	....	86	100
Gas as measured	cu. ft.	3,675	....	....
Ammonia as sulphate	lb.	11·7	15·1	Nil
Tar oils from liquor	gal.	12·6	14·1	8·5
Acids as acetic	lb.	11·8	6·8	....
80 per cent acetate of lime	"	19·5	8·3	105
Alcohols as methyl—				
Imp. gals. 100 per cent vol. basis		1·07	1·03	4·00
Imp. gals. 95 per cent vol. basis		1·12	1·08	4·25

TABLE XXVI

Comparison of Commercial Products in Hardwood Ovens and in Vertical Gas Retorts

Yields given on a basis of short ton (viz., 2,000 lb.) of peat charged

Products	Low temperature carbonization in wood ovens		High temperature carbonization in gas retorts	
Peat charcoal—				
Per cent of air-dried peat charged	37·2		25·1	
Pounds per ton	745		503	
Per cent ash (dry basis)	12·7		9·9	
Per cent volatile matter (dry basis)	28·7		3·9	
Calorific value B.T.U. per lb	11940		12650	
Peat tar oils—Imp. gals. per ton—				
Total produced	14·1 gals.		14·2 gals.	
Specific gravity at 60° F	0·968		0·992	
Fraction to 170° C. (dry basis)	6·7	per cent weight	2·5	per cent weight
" 170 to 230°C	25·8	"	13·9	"
" 230 to 270° C	17·5	"	15·4	"
" 270 to 335° C	24·0	"	34·7	"
Pitch and loss (by difference)	26·0	"	33·5	"
Aqueous liquor products per ton—				
Total liquor, (Imp.) gallons	86·0		87·0	
Ammonium sulphate, lbs	15·1		22·6	
Crude alcohol, (Imp.) gallons	1·08		0·34	
Gas—cu. ft. per ton	less than 4,000		about 12,000	
Crude motor spirits, (Imp.) gallons—				
Alcohol—plus oils below 170° C	2·10		0·75	

TABLE XXVII

Results of Analyses of Products

PEAT CHARCOAL—AVERAGE OF COMPOSITE FROM RUNS 1 AND 2

Proximate Analysis	As Rec'd basis	Dry basis
	%	%
Moisture	4·7	....
Ash	12·1	12·7
Volatile matter	27·4	28·7
Fixed carbon	55·8	58·6
Sulphur	0·27	0·28
Calorific value B.T.U. per lb	11385	11940
Weight per bushel	Average 35 lbs.	

PEAT PYROLIGNEOUS ACID

——	Run 1	Run 2
Specific gravity at 60° F	1,003	1,005
Reaction of liquor to litmus (Sl. Alk.=slightly alkaline)	Sl.Alk.	Sl.Alk.
Methyl (alcohol) spirits—c.c. per 100 c.c	1·10	1·30
Ammonia content—grm. per 100 c.c.	0·45	0·45
Total acids as acetic—grm. per 100 c.c	....	0·60

Peat Tar Oils—Composite Sample, Runs 1 and 2

Specific gravity at 60°F. of crude oil—0·968

Distillation Results	% Volume		Sp. Gr. of fraction
	Wet	Dry	
Water	3·0	....	....
Light oil up to 200° C	18·0	18·5	0·898
Middle oil 200 to 300°C	47·0	48·5	0·966
Heavy oil 300 to 335° C	10·0	10·3	0·934
Pitch (by diff.) above 335°C	22·0	22·7	....

In Table XXVI is given a comparison of the yields and composition of the commercial products obtained in the hardwood ovens by low temperature carbonization with those obtained at high temperatures in gas retorts. The latter results are those obtained by the British Fuel Research Board and which are published in their Technical Paper No. 4, under the title "The Carbonization of Peat in Vertical Gas Retorts." The air-dried peat used in these commercial-size gas retorts, when calculated on the 25 per cent moisture basis, conformed to the following analysis: 3·3 per cent ash, 46·6 per cent volatile matter, and 25·1 per cent fixed carbon, with a calorific value of 7,215 B.T.U. per pound. This analysis corresponds closely with the air-dried peat used for the low temperature runs at Longford, with the exception of ash, viz.: 3·3 as compared with 4·6. A comparison of yields and compositions of the commercial products as given in Table XXVII will be of interest.

Value of Peat Carbonization Products

Peat charcoal is to be considered the main product of low temperature carbonization with the tar oils, gas, and alcohol as by-products and of importance in the order given. By the high temperature processes especially where a large yield of gas is desired, the charcoal may be an equal or secondary product as compared with the gas. The charcoal produced by the wood ovens in many respects closely resembles wood charcoal. Its weight per bushel, however, is greater, averaging 35 pounds, as compared with 21 pounds for hardwood charcoal. At these weights per bushel, a ton of air-dried peat will yield only 21 bushels as compared with 26 bushels from a ton (half a cord) of hardwood. In view of the sale of the hardwood product in paper bags as a domestic fuel, peat charcoal if sold by bulk in a similar way would be of less value per unit weight. The value of the peat charcoal from a ton of air-dried peat is, therefore, disappointing in comparison with wood charcoal from an equal weight of hardwood. As a substitute for hardwood charcoal to be handled and sold in bags, at the same price per bag or bushel, 35 pounds of peat charcoal will net no more than 21 pounds of hardwood product.

Peat charcoal can be used for the same purposes as hardwood charcoal, e.g., starting and maintaining short-lived fires as in kitchen ranges, train dining-room stoves, and railway locomotives. For metallurgical purposes peat charcoal, or coke as it is sometimes termed, may prove of value. Should its structure be such that it could be used for this purpose its low sulphur content should be in its favour.

Peat charcoal as a household fuel does not possess, with the exception of a higher heating value, many advantages over air-dried peat with a moisture content of 20 per cent or below. The charcoal besides being dirty and difficult to handle in bulk tends to burn too rapidly in a furnace. As an open-grate fuel, however, peat charcoal may be considered a substitute for cannel coal. It should be worth pound for pound when sold in small or large sacks, as much as cannel coal which in small lots may sell for as high a price as $1.00 per 100 pounds. Discounting this figure 25 per cent, a conservative (wholesale) value of peat charcoal would be $\frac{3}{4}$ cents per pound, or $15.00 per short ton.

The peat tar oils, on preliminary examination, appear to be an oil mixture containing both creosote and paraffin, resembling wood tar oils on the one hand and crude petroleum on the other. A certain amount of light oils may be recovered as crude motor spirits, and other valuable products may be recovered, but at the present time it would be unwise to consider the heavier oils of greater value than crude fuel oil with a market value of 10 cents per gallon. Peat tar oils are good flotation agents[1] and for this purpose they may be worth as much as 20 to 25 cents per gallon as crude, unrefined oils.

The alcohol yield from peat was not so high as had been expected. The highest strength obtained in the laboratory was 90 per cent volume as per alcoholometer reading. The alcohol obtained in these commercial runs, has a similar boiling point range to that of crude wood alcohol and is miscible with water. The refined product as obtained in a commercial plant and containing 95 per cent alcohol by volume should be of value as a motor fuel especially when blended with certain of the light tar oils. This "methyl spirits", light peat oils product in the semi-refined state should be worth at least 20 cents per gallon for motor fuel purposes. Another possible use for these methyl spirits is as a denaturant for grain alcohol for the denatured alcohol market.

The cost of obtaining the different products from the peat liquor in comparison with their value, is a point to be considered. In respect to alcohol it is questionable if its value would be appreciably above the cost, as its percentage in the aqueous liquor is near the 1 per cent figure at which point the cost of refining is said to approach the value as a concentrated (crude) product. In respect to recovering the acid value of the liquor as acetate of lime the cost is considered prohibitive. For this reason no credit should be claimed for an acetate by-product.

The gas produced by carbonizing peat by the hardwood distillation process would be burned under the ovens thus allowing no credit for this product. The ammonia content of the uncondensed gases was not determined.

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[1] Crude peat tar oils as such and fractions from the same have been experimented with in the laboratories and ant of the Ore Dressing and Metallurgical Division of the Mines Branch, and found to be quite satisfactory in the tr eatment of many Canadian ores by the flotation process.

The ammonium sulphate yield given is that from the oven liquor to be obtained by the method outlined in the flow-sheet. Its value may be placed at 2 cents per pound.

The estimated value of the products from 2,000 pounds of air-dried peat may be summed up as follows:—

Peat charcoal—745 lbs. at ¾ c. per lb.	$ 5.60
Heavy tar oils—13 Imp. gals. at 10c. per gal.	1.30
Motor spirits—2 Imp. gals. at 20c. per gal.	0.40
Ammonium sulphate—15 lbs. at 2c. per lb.	0.30
Total value of products per short ton	$ 7.60

A rough estimate of the value of the products of a cord (4,000 pounds) of hardwood using recently prevailing wholesale prices, is as follows:—

Hardwood charcoal—1,100 lbs. at 1c. per lb.	$ 11.00
Crude alcohol—8½ Imp. gals. at 50c. per gal.	4.25
Acetate of lime (80%)—210 lbs. at 2c. per lb.	4.20
Tar oils—17½ gals. at 10c. per gal.	1.75
Total value of crude products per cord (2 tons)	$ 21.20

Using these figures for the value of charcoal and other products from peat, which would likely vary considerably from time to time, similar to the market value changes for hardwood products, and noting that a ton of hardwood is equivalent to only half a cord, the following comparison may be made:—

Value of products per ton of hardwoods	$ 10.60
Value of products per ton of peat	7.60

It will be noted that the ratio of the value of charcoal to the total value of products from peat would according to the above figures be roughly 75 per cent as compared with about 50 per cent for hardwoods.

Summary and Remarks

In this investigation a carload of air-dried peat with slightly over 25 per cent moisture content was carbonized in plant-size hardwood distillation ovens, under low temperature conditions. The rate of reaction was controlled at about 300° C. and the yields of the commercial products were measured, a preliminary examination of which has been made.

Air-dried peat bricks when handled and carbonized in the same manner as hardwoods responded to the same method of oven firing, but required slightly more fuel to carry on the carbonization during the later half of the run, which extra fuel was supplied by the oven gases produced. Although the oven firing did not require special attention to avoid a too rapid increase of the internal temperature of the ovens, there were indications of exothermic reaction, but not to the same extent as with hardwood. The moisture in the peat, however, apparently masked any appreciable outward signs of such reaction. The commercial products obtained were peat charcoal, peat tar oils, crude alcohol, and ammonia, of value in the order given. The alcohol when blended with certain light oils may be considered as a crude motor spirits product.

Peat charcoal in many respects resembles hardwood charcoal and as a special fuel for quick, hot and short-lived fires may be considered a substitute. The quality of the alcohol from peat, the yield of which is disappointingly low in comparison with hardwoods, has not as yet been thoroughly examined.

The weight per bushel of peat charcoal averaged 35 pounds as compared with 21 pounds per bushel for hardwood charcoal, and the yields per ton of raw material carbonized was roughly 21 bushels from peat and 26 bushels from hardwoods. At the same price per bushel to be marketed in bulk similar to the hardwood product, the value of the peat charcoal is, therefore, only about 0·8 of the value of the charcoal from an equal weight of hardwood.

The lumps of peat charcoal produced by carbonizing air-dried peat were irregular in shape and not so black as wood charcoal. Although apparently more friable than charcoal from hardwoods, the handling properties of the peat charcoal are such, that it can be used as a fuel in the condition produced and does not need to be briquetted.

The value of the products from air-dried peat is estimated as three-quarters of the value of the products from equal weight of hardwoods, and for peat the value of the charcoal as a percentage of the value of the total products is much higher than for hardwoods.

Once the cost of air-dried peat in large quantities is known, the yield figures given in this report may be used for determining the economic feasibility of carbonizing peat similar to the low temperature process as used for hardwoods. Until such a time, however, as the production of air-dried peat more than meets the demands as a household fuel, it is doubtful if the price of the raw material will allow the carbonization of peat to develop into an industry either to supplement a successful peat-harvesting enterprise, or in conjunction with the already established hardwood distillation industry.

CHAPTER XII

AGRICULTURAL USES OF PEAT AND PEAT LANDS[1]

Apart from their value as a source of fuel, the peat bogs of Canada have a high potential value from the standpoint of their use for agricultural purposes. Either they may be reclaimed, and by suitable treatment converted into valuable meadow and grazing land or highly productive crop areas, or the peat contained in them may constitute the raw material for manufacture of fertilizers and other products of service to the farmer.

RECLAMATION OF PEAT BOGS

Owing to the large areas of excellent agricultural land available, the reclamation of bog lands and their recovery for agricultural use has not become a live question in Canada. As the population increases, and land values rise, attention will no doubt be turned to the utilization for crop raising of the more favourably located bog areas. In some special cases, where such areas exist in the vicinity of centres of population, efforts to utilize them are likely to be made in the near future.

It will be of interest at the present time, therefore, to state briefly what steps have been taken in this direction in other countries, and to indicate the possibilities of bog reclamation in Canada, as well as the more important problems involved in carrying it out successfully.

Germany

The area of peat lands is estimated at about 5,000,000 acres, nearly four-fifths of which lie in Prussia. Prior to the war approximately 500,000 acres had been reclaimed and converted into farms. The work of reclamation was fostered and directed by the Prussian Government Peat Lands Commission, which was formed in 1876, and in the following year established an experimental station at Bremen.

Sweden

The Swedish Society for Peat Land Cultivation and Utilization was founded in 1886.[2] An experimental garden was established at Jönköping in 1889. Later on an institute with laboratories was built there, and experimental farms were started at Flahult and Torestorp. In 1918 the latter farm was given up, and a large experimental farm established two years later at Gisselås in the province of Jämtland. Since 1904 more than 150,000 acres have been reclaimed with the assistance of the Jönköping Station. Extensive analytical and research work is conducted at the laboratories. Three consulting peat engineers, each having a special district to supervise, are employed to investigate peat bogs and give advice and information to the farmers. Short courses in peat land reclamation

[1]Compiled by A. J. Forward, B.A.
[2]The Peat Bogs of Sweden and the Swedish Peat Society, by Dr. Hernfrid Witte, 1923.

and peat soil cultivation, attended by two or three hundred farmers from the whole country, are held annually at Flahult. Frequent meetings are held at different places for discussion, and in 1922 officials of the Society delivered about 140 lectures in various parts of the country. Illustration fields have also been established, and exhibitions are made at the agricultural shows. The Journal of the Peat Society "Svenska Mosskulturföreningens Tidskrift" has been published since 1887, and numerous circulars and pamphlets have been circulated.

Denmark

A scheme for reclamation of peat lands in the province of Jutland was inaugurated in 1866. More than 900,000 acres of heath and marsh-covered area have been cleared and made productive. The work of reclamation which now extends over the whole of Denmark is promoted by a State-aided society, under whose direction over 2,000 forest plantations aggregating 195,000 acres have been made.

Holland

Owing to the extensive use of peat as a fuel in Holland for centuries, vast areas of bog have been cleared of peat, and what were formerly sterile wastes have been turned into fertile fields. As a result important industries have been created, notably the manufacture on a large scale of starch and straw-board from potatoes and wheat grown on the reclaimed areas. In order to serve the peat-working colonies nearly 1,000 miles of canals have been dug in the three northern provinces alone, and these have provided transportation facilities which greatly favour the development of industries.

Austria, Russia, and Finland

In these countries much attention has been devoted to the agricultural use of peat lands. Large areas have been reclaimed, and extensive experimental work has been conducted by organizations largely financed by the Governments.

Great Britain

In England many thousands of acres of "fen" land have been reclaimed, and form some of the best potato land in the country, bringing as high as £50 to £80 per acre, and yielding annual profits as high as £15 to £20 per acre. In Lancashire 2,500 acres of the great bog known as the "Chat Moss," were purchased a few years ago by the Manchester Corporation and are now under cultivation. A tract of 1,400 acres of peat land on Dartmoor in the Duchy of Lancaster is being reclaimed by the Prince of Wales, the work being supervised by a Belgian expert.[1]

Although about one-seventh of the area of Ireland, or about 3,000,000 acres, consists of peat bogs, little action has been taken towards the utilization of these areas except as a source of fuel for the farming population.

[1] The Peat Resources of Ireland, by Prof. P. F. Purcell, 1919.

United States

About 700 square miles of the Dismal Swamp, which formerly covered an area of 2,200 square miles in Virginia and North Carolina, have been permanently drained to a depth of 3 feet or more by a large canal with feeders, and much of the drained land is under cultivation.

The southern part of Florida, known as the Everglades, consists of a peat and muck-covered district approximately 5,000 square miles in extent. During recent years extensive drainage operations in this territory have been conducted under the direction of a State Commission, and large quantities of citrus fruits and other products are now raised on what was formerly water-sodden waste land.

Peat deposits in Minnesota are estimated to have an area of over 5,000,000 acres. One county alone (Beltrami) has about 1,300,000 acres of peat lands.[1] Extensive drainage operations have been undertaken with a view to reclamation.

In Michigan and other states a very considerable acreage of reclaimed peat lands is cultivated with success, being largely devoted to truck growing.

Experimental work and special investigations relating to the agricultural use of peat lands are being actively carried on by the Bureau of Plant Industry, of the Department of Agriculture, in co-operation with the American Peat Society, and by observers at a number of University and State Agricultural Experimental Stations. The American Peat Society, organized in 1907, has for its objective the encouragement of the economic use of peat deposits in every practicable way in industry and agriculture. A consulting Committee has been formed, consisting of Government and private scientists of standing who advise members as to the use of their peat deposits without charge.

Legislation

Several European countries have passed laws governing the utilization of peat bogs for the manufacture of fuel. Under the Bog Preservation Law of Germany, which became operative in the province of Hanover in 1913, ground which alone or in connexion with other plots forms a bog of more than 25 hectares (62 acres), must be utilized for the winning of peat for fuel purposes in a manner such as to assure the possibility of its being used later on for agriculture or afforestation. Norway adopted similar legislation in the same year. Comprehensive regulations with the same object in view have existed in Holland since 1810.

BOG RECLAMATION IN CANADA

According to an estimate made a number of years ago, peat bogs cover about 37,000 square miles in Canada, but this probably represents only a fraction of the total area which from an agricultural point of view may be classed as peat land. However, the bulk of these lands are remote from settled areas, and, owing to their northerly situation, climatic conditions will create special problems in their utilization for agricultural purposes.

[1] The Occurrence and Uses of Peat in the United States, by E. K. Soper and C. C. Osbon, U.S. Geol. Surv. Bull. No. 728.

Since 1908 over 100 bogs covering an aggregate area of 228,367 acres, have been surveyed and investigated in detail, primarily as to their suitability for the manufacture of peat fuel and moss litter. Preliminary investigation has been made of additional areas aggregating 350,000 acres in the province of Manitoba. These latter have been found, as a rule, to be comparatively shallow, and to contain little well-humified peat adapted to serve as raw material for fuel production, but are reported in most cases as being suitable for agricultural utilization.

Where peat-fuel-manufacturing operations are carried on, it may be found advantageous to devote portions of the bogs being worked upon to agricultural uses. The marginal areas about many bogs are too shallow or contain too little well-humified peat to be worked economically for fuel production. The acreage of those portions of a few of the larger bogs investigated in which the deposit is less than five feet in depth, is as follows:—

Bog	Province	Total area, acres	Area less than 5 ft. deep, acres
Holland	Ontario	14,640	9,084
Mer Bleu	"	5,000	1,564
Welland	"	4,900	1,435
Richmond	"	5,500	3,340
Verona	"	6,830	1,426
Large Tea Field	Quebec	5,270	1,970
Small Tea Field	"	4,190	1,800
Lanoraie	"	7,500	3,966
Holton	"	6,180	2,703

Large areas of shallow peat lands adjoining many of the bogs have already been brought under cultivation.

Finally, when the peat deposits have been removed for the manufacture of fuel, the underlying soil, where it can be efficiently drained, may be recovered for agricultural use. In some European countries, as already mentioned, the winning of peat for fuel is conducted under regulations which ensure the leaving of the surface from which the peat has been removed, in condition suitable for cultivation.

PROBLEMS OF RECLAMATION

The main difficulties to be overcome in the successful utilization of peat-covered areas for growing crops are due, first, to the situation of such lands, and, second, to the peculiar nature of the soil.

Peat usually occurs on flat areas and in more or less shallow depressions which are poorly drained, so that the surface is always wet or covered by water. Drainage is, therefore, the first problem encountered. The feasibility and cost of drainage may in many instances prove the determining factor in the reclamation of any particular area.

Most peat land areas are at least partially covered with growing spruce, tamarac, and other trees and shrubs, principally heaths; and the covering moss and surface soil are more or less encumbered with roots and trunks of trees and shrubs. The clearing and preparation of such areas for the plough is an expensive operation.

The difficulties arising from the nature of the soil are important, and many cases of disappointment and failure in the cultivation of peat lands have occurred from lack of knowledge of the special character of peat soils.

The high water-holding capacity of peat makes it cold under moist conditions, since the water held must be warmed as well as the soil. On the other hand, when dry, the soil heats quickly, but radiates its acquired heat more rapidly than any other soil, making it very warm during the day and cold at night. When thoroughly dried out the soil particles become to some degree impervious to water and do not readily become wet again. Owing to the fact that the soil contains undecomposed plant structural material, much of the water is held in the remains of the plant cells and tissues of which it is composed, and is not available for absorption by the roots of growing plants. A peat soil is hard to control in seasons of drought, and the supplying of the proper degree of moisture to growing plants is a problem demanding special care and attention.

On account of its loose structure, and lack of firmness and compactness when dry, it does not give good root hold to crops. Because it is so wet during the fall and spring, crop plants wintered on this type of soil are very liable to injury from frost "heaving."

Finally, while rich in some plant foods, it is usually very deficient in others, or where present these occur in such combinations with other substances that they are not readily available for plant nourishment. As a rule peat soils are acid, and unfavourable to the nourishment of bacterial organisms until their acidity is corrected by mineral applications, and the action of the sun and air.

Preliminary Investigation Required

Peat soils vary widely in both their physical and chemical properties, and in their suitability for the growing of crops. Before reclamation of any particular area is attempted, the character and properties of the deposit and its adaptability to crop production, should be determined. The investigations of peat bogs hitherto made by the Mines Branch, have had for the main object the ascertaining the suitability of the peat contained therein as a raw material for the manufacture of fuel or moss litter. Further investigations are necessary before their suitability for agricultural use can be estimated.

Structural studies are important. Peat occurs in stratified layers, which may have been deposited under different conditions, and which, in many cases, vary materially in character at various depths from the surface. Not only the depth of the deposit and the nature of the mineral subsoil have an important bearing, but the thickness of the layers, as well as their varying physical characteristics and chemical composition, may seriously affect the problem of cultivation.

Chemical analyses while of importance are not to be solely relied upon since for the most part the plant food materials present in peat are in an inert condition, and become available for the nourishment of plants and soil organisms only after continued exposure of the soil to aeration, and its treatment with fertilizers.

The physical properties of the peat—its comparative density, porosity, and humus content largely control the movement and amount of air and water in the soil—have a marked effect upon the absorption of gases, and may increase or reduce the growth and development of micro-organisms and affect the nutritive conditions of the root systems of crops.

Drainage

A proper system of drainage is essential to the successful cultivation of peat lands. The water must be lowered sufficiently to produce a firm surface for working upon with horses or machinery, but not low enough to endanger the crops by drought. The extent to which the water-table should be lowered depends somewhat on climatic conditions, and will vary according to the average rainfall. In warm climates with a heavy rainfall, such as 60 to 80 inches per year, there is no danger of depressing the water too much, but in the cooler climate of Canada, where the average rainfall is much less, the depth of drainage is an important factor to be considered. In Minnesota, where attention has been directed for some years to the cultivation of peat lands, the highest yields are obtained with the water at a depth of not more than 20 to 40 inches.[1] The most favourable depth in given cases depends upon the particular crop to be raised.

The drainage of peat lands is a much more complex problem than that of draining ordinary mineral soils. One of the most remarkable properties of peat is its capacity for retaining water. The construction of main drains alone is for this reason ineffective. For efficient drainage a comparatively large number of shallow drains must be provided to lead the surface water to the main drains.

Shrinkage and settling of the soil as a result of drainage is very marked. Peat in an undrained deposit has usually a water content of 90 per cent or upwards. If in consequence of drainage operations, the water content is reduced from 90 per cent to 85 per cent, the resulting shrinkage in volume will be approximately one-third. In sections of the Everglades of Florida, where peat soil 10 to 12 feet in depth has been drained or partly so, it has been observed that the surface level was lowered 2 to 3½ feet in six years, and subsidence was still continuing.[2] Owing to the rapid settlement of the surface which is caused by drainage, the surface drains require deepening from time to time until a permanent level is established. Both the depth of the deposit and the nature of the peat soil materially affect the problem of drainage of any particular area.

The distance between the drains will vary with the type of soil and other local conditions. Tile drains though expensive to install generally prove more satisfactory and ultimately more economical than open ditches

[1] Some Limitations on the Cultivation of Peat Lands in Minnesota, by F. J. Alway—Jour. Am. Peat Soc., Vol. IX, No. 2.

[2] Results of Run-off Experiments with Muck Soils, by F. C. Elliott, Florida Engineering Society Year Book, 1921.

which must frequently be dredged. Experience shows, however, that it is not good practice to tile immediately after the surface water has been removed, but that it is preferable to drain by open surface cuts to main ditches and to defer the laying of tiles until settling has ceased. Drains to intercept seepage from adjoining higher lands are in some cases important.

Since the efficiency and suitability of the drainage system will have an important bearing on the success of the agricultural operations to be carried on, any attempt made to reclaim peat lands on other than a very small scale should be conducted only under the supervision of a qualified engineer, with experience in reclamation of such lands for agricultural use.

Clearing

The difficulty and cost of clearing vary widely. For this purpose heavy tractors and special breaking-ploughs have been used to advantage.[1] As a rule stumps are shallow-rooted and the soil loose so that they can be pulled with a team and a simple stump-pulling device.

It is a common practice to set fires during the dry summer season to burn off the brush and surface moss. This practice is not only a source of danger, but has serious disadvantages. Fire in peat or muck is hard to control, and once started may go on burning until extinguished by fall rains or winter snow. Where the peat or muck deposit is shallow it may be entirely destroyed leaving in many cases only a barren mineral subsoil.

Summer Frosts

Peat soils are especially subject to summer frosts.

Observations made during the season of 1914, at the Experimental Farm, Grand Rapids, Minn., showed differences ranging from 3 to 19 degrees between the minimum temperatures on the surface of a cultivated bog and on adjacent mineral lands.[2]

Covering the peat with sand, clay, or loam reduces the danger of frost and makes the night temperatures similar to those of the surrounding land. This method is practised to some extent in Sweden. Studies made in the cranberry regions of Wisconsin showed that the temperature two inches above poorly drained peat land covered with grass and cranberry vines is frequently 8 to 12 degrees lower during the night than that over a well-drained sanded bog.[3] Since, however, an application of 80 to 320 cubic yards per acre is required, the expense involved is considerable. The sand-cover method, also, is only safely applicable to shallow peat deposits, well decomposed, and well supplied with lime.[4]

Rolling is an important factor in frost protection on peat soils. A well-compacted muck or peat soil will not frost so readily as one that is loose. Fertilization may also play an important part since injury by frost is less where the growth of crops has been most vigorous.

[1] The Financial Side of Muck Land Development, by W. C. Steenburg, Jour. Am. Peat Soc., Vol. XVII, No. 1.

[2] Some Limitations on the Cultivation of Peat Lands in Minnesota, by F. J. Alway, Jour. Am. Peat Soc., Vol. VII, No. 2.

[3] The Development of Marsh Soils in Wisconsin, by A. R. Whitson, Jour. Am. Peat Soc., Vol. XIII, No. 3.

[4] Chemical Requirements of Peat Soils in the Light of European Experience, by F. J. Alway, Jour. Am. Peat Soc., Vol. XIII, No. 3.

Nature of Peat Soil

Soils are classified according to the relative abundance of their constituents. Ordinary sand, loam and clay soils consist mainly of rock material. Peat deposits on the other hand are accumulations of organic matter derived from the debris of plants grown under conditions unfavourable to decomposition. The only mineral elements present in such a deposit are those derived from the organic remains of plants and animals, and those precipitated from the water, or carried into the bog from the surrounding lands by the action of wind or drainage waters.

Thus peat soils, although extraordinarily rich in organic matter, are deficient in mineral constituents necessary to fertility, and possess physical characteristics which give rise to special problems in their cultivation. Such soils are also of widely varying types requiring altogether different treatment. Experience gained in farming on ordinary soils is largely inapplicable to the working of peat soils. On the former, operations must be conducted largely with a view to keeping up or increasing the supply of organic matter in the soil. The successful cultivation of peat soils depends rather upon supplying the deficiency of the needed mineral elements, and dealing with the special physical conditions encountered.

The character of the vegetation from which a peat deposit has been formed determines to a great extent the nature of the soil and the treatment required for its successful cultivation. This varies widely in different bogs and even in the same bog. Grass peat soils are usually well suited for agricultural purposes. Hypnum moss requires lime for its growth, and hypnum bogs occur only where the water contains lime. The soil of bogs of this description is rich in lime as well as nitrogen, and is generally well adapted for agricultural use.

Sphagnum moss flourishes under acid conditions and where sphagnum is the principal constituent of the peat liming is required to correct its acidity as a preliminary to any attempt at raising ordinary farm or garden crops.

Peat soils are usually of complex composition so far as the constituent vegetation is concerned, and careful study is required of any particular deposit which it is proposed to reclaim for agricultural use.

Peat soils are very light, their weight per acre-foot being only one-seventh to one-eighth that of mineral soils. Their loose, open texture affects both the soil temperatures and the foothold offered to crops. Their mechanical condition is, therefore, an important factor in determining growth, and the compacting of the soil by the use of heavy rollers is a necessary measure to ensure successful cultivation.

Necessity for Mineral Fertilizers

Practically all peat soils require addition of mineral elements necessary to fertility. The problem of their fertilization is by no means simple, and the requirement of any particular deposit must be ascertained by soil analyses supplemented by records of experience in the cultivation of similar soils elsewhere.

In several European countries peat lands have been extensively cultivated for many years past, and numerous articles, pamphlets, and reports have been published containing much valuable information as to the management of such lands, experience with various crops, etc.

In recent years considerable attention has been directed to the cultivation of peat and muck lands in the United States. Experience has shown the absolute necessity for mineral fertilizers on this class of soils. The addition of potash is generally necessary for all peat soils. Where the deposits are shallow enough after settling to permit deep ploughing to reach the clay or silt subsoil the need of potash fertilizers becomes greatly diminished.[1] Phosphate requirements are not nearly so universal. While lime is needed on deposits deficient in lime, too heavy applications may be actually injurious.

Not only the initial application of mineral fertilizers to supply elements lacking in the soil is essential, but the continuation of their use is important. The continual dissolution of rock particles in ordinary soils replenishes to some extent the mineral elements necessary to fertility. Peat soils being composed of organic matter afford no means of restoration of these elements when exhausted by crops. Fleischer[2] estimates that a crop of 3 tons of hay per acre will remove from the soil the equivalent of 300 pounds of 40 per cent potash salts, and 250 pounds of 16 per cent acid phosphate. Mineral elements withdrawn must be supplied by annual applications of fertilizers, in order to maintain fertility. Commercial fertilizers alone have been found by the Swedish experimental station to be insufficient to maintain maximum yields, and light applications of stable manure are recommended in order to provide bacteria of decay.[3]

Crops Suitable to Peat Soils

The acidity of peat soils makes them especially valuable for cranberry culture and the raising of blueberries. A considerable percentage of the cranberry crop of the United States is produced on the peat marshes of Wisconsin where several thousand acres are devoted to this crop.[4]

Experiments in the commercial growth of blueberries on peat soils have been carried on for a number of years in New Jersey.[5] The swamp blueberry (*Vaccinium Corymbosum*), the most desirable species for cultivation, thrives best in acid soil, especially one composed of peat and sand, and for best results requires good drainage, thorough aeration of the surface soil, and permanent, but moderate, soil moisture. Plants do not come into bearing until three or four years old. Wild bushes live to a great age often 50 or 100 years. A small plantation in Elkhart, Indiana, started in 1889, produced an average yield of over 2,000 quarts per acre in 1911-1915, yielding, at an average price of 14 cents, an annual profit of $137 per acre.

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[1] The Development of Marsh Soils in Wisconsin, by A. R. Whitson, Jour. Am. Peat Soc., Vol. XIII, No. 3.
[2] Die Anlage und die Bewirtschaftung von Moorwiesen und Moorweiden, M. Fleischer, 1913.
[3] Chemical Requirements of Peat Soils, by F. J. Alway.
[4] Peat Resources of Wisconsin, by F. W. Huels, Bulletin XLV, Wisconsin Geological & Natural History Survey, 1915.
[5] Directions for Blueberry Culture, by F. V. Coville. U.S. Dept. of Agriculture, Bulletin 334, 1916.

Only a beginning has been made in the improvement of the blueberry, but by selection of superior wild strains and hybridization, berries seven-eighths of an inch in diameter have been produced. Blueberry culture, when improved strains have been developed, may become a profitable industry, and lead to the utilization of lands otherwise almost valueless. Some American nurserymen now offer plants for sale in their catalogues.

Intensive farming of peat soils has been carried on successfully for a number of years in some districts of the United States. In southern and western Michigan, in the vicinity of Kalamazoo, Grand Haven, Muskegon, and other centres of population, numerous small farms of one to fifty acres are devoted to vegetable culture, the main crops being celery and onions. Lettuce and cabbage are also extensively grown. Onions are a standard and reliable crop on peat soils. Celery probably gives the greatest returns per acre but is an expensive crop to produce, requiring more expert labour and heavier fertilizing than any of the other crops commonly grown on peat soils.

In addition to celery and onions, lettuce, cabbage, spinach, kale, cauliflower, sweet corn[1], and peppermint, are among the most important crops now grown with success on peat soils.

Restrictions imposed by the markets available, cost of fertilizers, etc., strictly limit the aggregate area of peat lands which can be profitably employed in intensive farming for the production of vegetables.

The efforts of plant breeders have hitherto been almost entirely directed towards the production of varieties and strains which would yield the best results when grown on ordinary mineral soils. The breeding and development of strains best adapted to the special conditions of growth on peat and muck soils is a promising field for experiment, and may, eventually, materially affect the productive capacity and value of such soils.

Any extensive reclamation of peat lands must depend on general farm crops. Peat soils will make good pasture, and are especially well adapted to the growing of hay. Observations in southern Michigan indicated that in that locality about six weeks additional pasture was obtained in the season, as compared with high land pastures.[1] It may be observed that the grasses developed for use on high lands are not in many cases well adapted for use on peat soils. However, further experiment with native grasses with particular reference to their utility on such soils, may have great possibilities in improving the yield of pasture and hay on peat lands.

The sale of hay from high land farms is poor economy, because the soil soon becomes depleted of nitrogen and organic matter. Owing to the large amounts of these elements present in peat soil there is no such danger of exhaustion, and hay may be a valuable cash crop on peat lands.

The small grains are not dependable on peat lands. The rank growth of weak straw tends to create difficulty through lodging, and retards maturing of the crop. The use of mineral fertilizers, heavy seeding, and thorough rolling of the seed bed, will to some extent overcome these difficulties. Based on experience in Michigan, oats will give the best results, then barley, rye, and wheat, in the order named.

[1] Muck Farm Management in Michigan, by Ezra Levin, Jour. Am. Peat Soc., Vol. XIII, No. 3.

Corn has been successfully grown for ensilage, but does not mature so well as on high lands, and does not give so high a quality of ensilage. Oats and peas, soy-beans and sunflowers are also grown for ensilage.

Potatoes do well, but are inclined to be watery, unless the crop is well fertilized.

Sugar beets are regarded as an important crop for the development of Michigan peat and muck lands. Some of the best beet fields in the state are in muck soil.[1]

NITROGEN CONTENT

The peat in Canadian bogs so far investigated has a high nitrogen content which is valuable as a potential source of fertilizer. The fertilizing value of the nitrogen of peat deposits may be turned to account by utilizing peat:

(1) As a raw material for the production of sulphate of ammonia or nitrates.
(2) As an ingredient in chemical fertilizers.
(3) In a prepared form for direct application to the soil.
(4) For composting with manure.
(5) As a carrier for bacteria.

Peat as a Source of Sulphate of Ammonia

As stated in a previous chapter of this report, the peat in Canadian bogs so far examined has, as a general rule, a high nitrogen content, from 1 to 2·8 per cent.

The feasibility of establishing by-product recovery plants in Canada for the production of ammonium sulphate from peat has been discussed in Chapter IX of this report.

Use in Manufacture of Chemical Fertilizers

Nitrogen, phosphoric acid and potassium, which are used in the manufacture of chemical fertilizers must be employed in a form which plants can assimilate. In a ton of 3-9-3 fertilizer there are 300 pounds of chemicals for plant nourishment, and 1,700 pounds of salts, organic matter, etc., which are necessary to condition the product for use.[2] Various substances are used to supply the needed volume of organic matter, and for this purpose peat has special advantages. Owing to its high water-holding capacity, its employment gives a product of excellent mechanical condition. The addition of peat will overcome any tendency to cake, and the fertilizer thus produced can be conveniently bagged and easily drilled. From a commercial point of view, uniformity of colour of the finished product is desirable, and this is easily secured by the use of peat. Many

[1] Muck Farm Management in Michigan, by Ezra Levin, Jour. Am. Peat Soc., Vol. XIII, No. 3.
[2] The Use of Peat in Commercial Fertilization, by H. E. Wildeman, Jour. Am. Peat Soc., Vol. IX, No. 1.

of the substances commonly used as fertilizer "fillers" have little or no value as plant food, and some contain material which is deleterious to plant growth. Peat, on the other hand, is rich in humus, and supplies additional nitrogen as well as organic matter to the soil. Although these are to a great extent not immediately available as a source of plant food or nourishment for soil organisms, they gradually become so under the conditions found in a cultivated soil. Peat derived from an area which has been for some time under cultivation is, therefore, preferable to raw peat for use in fertilizers.

The use of peat in commercial fertilizers also facilitates the use of fertilizing materials which are otherwise difficult to handle. Many kinds of waste matter from packing houses are hygroscopic and absorb moisture from the air, and either cake into hard masses or give off offensive odours, which indicate loss of nitrogenous matter. Peat not only prevents to a large extent such decomposition, but acts as an absorbent when decomposition does occur, thereby retaining valuable gases in the product. Tankage to which about 40 per cent peat has been added gives a uniform product of excellent mechanical condition and rich in ammonia.

Garbage tankage is a low grade of fertilizer material not only on account of its low ammonia content, but also on account of its peculiar mechanical condition. The addition of peat to the tankage as it enters the driers results in a greatly improved product, and the offensive odours incident to garbage reduction are also largely eliminated.

The use of peat in the preparation of fertilizer from fish improves the physical condition of the scrap, prevents disagreeable odours, and reduces the danger of fire. Fish scrap contains a considerable amount of oil, the presence of which leads to heating and danger of fire from spontaneous combustion. When peat is added the oil is largely absorbed by it, and held in such a manner as to greatly reduce the danger of heating. The offensive odour of the product is also greatly reduced, and fish scrap when mixed with peat can be more readily mechanically mixed with other fertilizer materials.

The extent to which peat has been employed in the United States in the manufacture of commercial fertilizers has been already indicated in Chapter VIII, (see Table XVI).

Composting with Manure

The value of peat for this purpose is unquestionable. Besides conserving valuable fertilizing elements of the manure which would otherwise be lost, it adds a considerable amount of nitrogen to the product. Prof. Robinson of the Michigan Agricultural College states that the value of farmyard manure would be practically doubled by composting with one-third its weight of peat containing 2 per cent nitrogen[1]. By the use of a mixture of peat and manure nitrification is apparently accelerated, and the inert nitrogen compounds are made available more quickly than when these materials are used separately.

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[1] Utilization of Muck Lands, by C. S. Robinson, Michigan Agricultural College Experimental Station, Bulletin No. 273.

Bacterized Peat

Bio-chemical research has led to an accumulation of evidence that the organic matter of the soil with its bacterial population is the most essential factor in soil fertility.

The fertilizing effect on the soil of growing clover and other leguminous crops has long been known. In 1888 it was found by Beijerinck that the bacteria in the root nodules of the legumes can absorb nitrogen from the soil air and combine it with other elements to form nitrogenous plant foods.

Upon this discovery was based the theory of soil inoculation with bacterial cultures.

Prof. W. B. Bottomley of King's College, London, after several years of experimental work announced that specially treated peat had been found a most suitable material to serve as a medium for nitrogen-fixing bacteria, and gave to the bacterized peat the name "Humogen."[1]

Remarkable results were obtained in greenhouse and small plot experiments, from the use of bacterized peat as a fertilizer[2], and great expectations were based on the possibilities arising from its extensive use in field cultivation. Later trials in field plots led to the conclusion that, so far as the raising of farm crops is concerned, the large amount of the material required to produce fertilizing values equivalent to those of the fertilizers ordinarily employed would make it too costly for employment in general agriculture.

The use of bacterial fertilizers is, however, well established, and the potential use of peat as a medium for supplying to the soil bacteria favourable to the growth of crops is of such importance as to demand continued investigation and experiment.

Use of Raw Peat as a Manure

Raw peat applied directly to ordinary soils frequently has but little fertilizing value. Until its acidity has been corrected by exposure to sun and wind for a considerable period, it is not in a condition favourable to the life of bacterial organisms which aid fertility, and the nitrogen contained is largely in a form unavailable by plants. Where the application, however, is of sufficient quantity the physical effects from it may be of importance. These are mainly:—

1. Lightening of the soil, and increasing its looseness and openness of texture, thereby promoting soil aeration.
2. Increasing the capacity of the soil to absorb moisture.
3. Decreasing the rate of evaporation of water from the soil, enabling it to retain moisture for a longer period.
4. Increasing absorption of solar heat.

[1] The Bacterial Treatment of Peat, by W. B. Bottomley, Jour. Can. Peat Soc., Vol. III, No. 2 (From Journal of the Royal Society of Arts).
[2] The Spirit of the Soil, by Gordon D. Knox.

MOSS LITTER

Peat moss, on account of its absorbent and deodorant qualities, is a material specially well adapted to serve as stable litter. By absorbing the liquid manure the most valuable portion is saved since it contains, ordinarily, over half of the nitrogen and four-fifths of the potash of the total manure. Furthermore, the plant food in the liquid form is immediately available for plant use while the solid manure must first be decomposed in the soil before its fertilizing elements can be taken up by the crops. Barns in which peat is used as litter are notably free from the usual characteristic odour of manure. Peat litter also adds considerable fertilizing value to the manure in the form of nitrogen compounds and organic matter. The following table showing the comparative absorptive efficiency of various materials used as litter is the result of experiments made at the Michigan Agricultural College Experimental Station.[1]

TABLE XXVIII

Comparative Absorptive Efficiency of Various Materials

Sample No.	Material	Pounds water absorbed by 100 pounds material	Quantity water absorbed by other materials compared to quantity absorbed by straw
1	Excelsior	283·9	0·76
2	Shavings	288·4	0·77
3	Straw	374·3	1·00
4	Muck, black	381·8	1·02
5	Muck, black	387·3	1·03
6	Marsh hay	417·2	1·11
7	Muck, brown	558·7	1·49
8	Sawdust	750·9	2·01
9	Peat, brown	850·8	2·27
10	Peat, brown	1,625·3	4·34

The use of moss litter as bedding for horses and cattle has for many years been extensive in Europe, and its manufacture and marketing is, particularly in Holland, an industry of some importance. It is manufactured from sphagnum peat, which must be as little humified as possible in order to be suitable for making first class moss litter. Peat for the manufacture of litter is dug in the autumn, work continuing until frost sets in. The peat dug is laid out on the surface of the bog and left there until spring. The freezing of the peat is advantageous since the fibres in the peat are broken up by the frost, disintegration is made easier, and the subsequent drying process is facilitated. In cases where peat suitable for fuel and litter are found in the same bog, the manufacture of moss litter can be combined with that of peat fuel to advantage, thereby lengthening the operating season and the period of employment of workmen.

A simple method is frequently employed by farmers to prepare comparatively small quantities of litter for use on their own farms. A part of the bog, sufficiently drained to allow the use of horses on its surface,

[1] Utilization of Muck Lands, by C. S. Robinson, Michigan Agricultural College Experimental Station, Bulletin 273.

is ploughed to a depth of six or eight inches in the fall. The following spring the peat is thoroughly harrowed, and when sufficiently air-dried, is scraped into heaps, conveyed to a storehouse and used as required. The surface can be harrowed several times during the summer, as the peat, spread out in a thin loose layer, is quickly dried by the wind and sun.

For commercial production the peat is cut into blocks, dried on the surface of the bog, and brought to a plant where it is disintegrated by machines and pressed into bales. Where it is desired to obtain peat mull as a separate product, the disintegrated material is passed over sieves which separate the dust or mull from the fibre. Disintegrators and presses of different sizes and capacities and for both hand and motor power are manufactured by a number of firms in Europe.

USE OF PEAT IN STOCK FOODS

Peat mull, obtained by screening the peat shredded for stable litter has long been used in Europe as the basis for stock foods made by mixing it with refuse molasses. While molasses is an excellent fattening food for stock, it is difficult to feed on account of its physical properties and its effects on the digestive organs. When mixed in proper proportions with peat powder it is readily eaten by livestock, which are greatly improved in condition and weight by its use. It is claimed that as high as 50 per cent of molasses may be used in a stock food when mixed with peat. The corrective qualities of peat make it a desirable material also for mixture with cotton seed meal. Considerable quantities of peat are used annually in the United States in compounding stock foods. (See Table XVII.)

AS A PACKING MATERIAL AND FOR INSULATION

Both moss litter and peat mull are valuable packing materials. Moss litter is light and elastic and can be employed to advantage in packing perishable wares and products. It is a poor heat conductor and can be used for keeping ice, protecting pipes from frost, covering steam pipes and boilers, and, when thoroughly protected from moisture, as an insulating material in buildings.

Peat mull is of especial value for the packing and preservation in storage of perishable fruits and vegetables. E. Nystrom has obtained favourable results from experiments in the preservation of apples in peat mull in Sweden.[1]

PEAT MULL FOR SANITARY PURPOSES

The absorbent and deodorant, as well as to some extent disinfectant, properties of peat mull (peat dust) make it a very desirable material for use in earth closets, cess pools, etc. In places where there is no public water supply or sewage disposal system, its use for this purpose would be in the interest of public health. In many European towns such use is made compulsory.

[1] An Investigation as to Preservation of Apples in Peat Mull, by E. Nystrom, (Translation) Jour. Can. Peat Soc., Vol. II, No. 3.

APPENDICES

APPENDIX A

INVESTIGATION OF DRYING CONDITIONS OBTAINING DURING THE MANUFACTURE OF PEAT FUEL AT THE ALFRED PEAT BOG

OBSERVATIONS AND CHEMICAL TESTS

Harald A. Leverin[1]

Chemist, Mines Branch, Department of Mines

Inasmuch as reliable data regarding drying conditions on the Alfred bog, as well as the determination of the length of the season during which peat can be manufactured and dried to produce a commercial fuel, is of general interest, the Peat Committee decided to keep records of the atmospheric conditions, temperature, barometric pressure, humidity and precipitation, concurrently taking samples of peat from the drying-field and determining their water content. For that purpose self-registering instruments—thermometer, barometer, hygrometer and rain-guage—all of the Negretti and Zambra make, were installed on the bog in accordance with instructions received from the Meteorological Service in Toronto. The instruments recorded the variations of atmospheric conditions on charts, for a period of one week, from which the average was determined, and compared with the rate of evaporation indicated by the samples taken.

Observations were continued during the four seasons of operation and the results thus obtained have been compiled and curves plotted showing the weather conditions and the relative rates of drying of peat spread on the drying-ground at different periods during each season.

In interpreting these curves it must be borne in mind that the work carried on by the Peat Committee at Alfred had as its objective the development of machines for the manufacture of peat, rather than the actual production of peat fuel, and that the experimental nature of its work caused a lack of uniformity in some respects which would not occur in ordinary commercial operation. Thus changes made, both in the maceration of the raw peat, and in the manner of spreading the peat pulp on the drying-ground, led to variations of the drying conditions of the peat spread.

Since the rate of drying of peat in the open air is materially affected by the thickness of spreading, experimental plots were spread with depths of 4, 5, and 6 inches, in order to determine the comparative lengths of time required for the drying of peat of these thicknesses.

[1]Through the courtesy of the Mines Branch of the Department of Mines the services of H. A. Leverin were loaned to the Peat Committee to conduct this investigation.

CHARACTER OF THE RAW PEAT

The peat in the Alfred bog is a suitable material for the manufacture of peat fuel. It is well humified and uniform throughout the area, with the exception of small sections at the north and the west ends, where the bog becomes shallow, 4 to 5 feet in depth, and as a consequence the amount of moss and partly humified peat is large in proportion to the well-humified peat. The peat manufactured from the rest of the bog is an excellent peat fuel, fully equal in quality to any samples of manufactured peat obtained from foreign or domestic sources.

Results of the moisture determinations of the bog were variable. Samples taken from the working-face alongside the Canadian Pacific railway at the west end of the bog and every 1,000 feet eastward, had moisture contents of 85·3, 88·0, 87·7, and 88·0 per cent, respectively. Samples taken along the working-face of the cut running from north to south showed 88·0, 87·0, 87·7, and 88·0 per cent of water content, respectively. Eliminating that part at the west end of the bog, which, owing to its shallowness and to the numerous stumps, roots and trunks of trees contained, is unsuitable for the manufacture of peat fuel, the average water content would be 87·8 per cent. The macerated raw peat spread on the drying-ground had almost invariably a water content of 90 per cent.

No difference in specific gravity was found in the various samples. This, as determined for the bog, was found to be 1·009.

Analyses of the peat dried at 110° C. gave the following values:

Volatile combustible matter	68·23	per cent
Fixed carbon	26·00	"
Ash	5·77	"
	100·00	"
Nitrogen	1·76	per cent
Phosphorus	0·033	"
Sulphur	0·218	"
Calorific value	9005	B.T.U.

The ash is light, contains no cinders, and has the following composition:

Silica (SiO_2)	18·7	per cent
Alumina (Al_2O_3)	9·6	"
Ferric oxide (Fe_2O_3)	7·6	"
Lime (CaO)	31·6	"
Magnesia (MgO)	14·6	"
Potash (K_2O)	0·8	"
Soda (Na_2O)	4·7	"
Sulphuric acid (SO_3)	3·9	"
Phosphoric acid (P_2O_5)	1·3	"
Carbonic acid (by diff.)	7·2	"
	100·0	"

THE DRYING-GROUND

The nature of the drying-ground plays an important part in the drying of peat. At Alfred the raw peat was spread over the areas of the bog adjacent to the working-faces of the trenches. Shallow cross-ditches emptying into the main excavations at regular intervals served to provide a sufficiently dry surface, with fairly uniform moisture content.

The Alfred bog, in a state of nature, is covered with a dense growth of low shrubs, mostly heaths, about 18 inches high. When these are pressed down by the spreader, they provide a favourable drying-surface, preventing the spread peat from coming into direct contact with the often wet surface of the bog. After being spread over with peat for two or more successive seasons, these shrubs die down, leaving the moss exposed. Under favourable weather conditions this affords an excellent drying-surface, but since different varieties of moss absorb various amounts of water, drying on such a surface is not altogether uniform, and it is a common occurrence to find pieces of dry and wet peat lying alongside each other. Where the surface covering of moss has been destroyed by fire, the peat laid down comes in direct contact with the wet surface of the bog and drying is greatly retarded, and unless weather conditions are exceptionally favourable, it is impossible to obtain a marketable product.

A portion of the drying-field employed at Alfred had been used during earlier operations, but considerable areas were cleared and used for the first time. Experience in drying under all the three conditions above referred to was, therefore, gained. Two other factors which affected the results obtained in drying remain to be mentioned.

On some portions of the drying-field which had been previously used, excavated peat had been left lying on the ground, and becoming disintegrated, coated the surface with a layer of dust which readily absorbed moisture, creating over such areas a condition in some respects similar to that on burned spots.

It was observed that on those areas which had been most travelled over, there occurred a growth of vegetation, grasses, etc., different in character from that of the bog itself. To facilitate this, and to improve the condition of burned-over spots and areas covered with disintegrated peat, an experimental seeding of portions of the drying-ground was made in 1921, and during the final year's operation it was found that substantial improvement had been effected.

The varying conditions of the drying-areas during the operations were to a large degree responsible for lack of uniformity in moisture content of the peat fuel manufactured and shipped to consumers.

METHOD OF SPREADING

The macerated raw peat was spread on the drying-ground in long strips of the desired thickness and about 12 feet in width, which were subsequently divided into blocks by mechanically operated cutting-devices. Two types of spreaders were employed. Peat spread during the first two seasons by a modified Jakobson field-press, owing to more uneven thickness of spreading and closer contact of the peat with the surface of the drying-ground, was left on the field in less favourable condition for drying than that spread with the type of machine used with the Moore plant in 1921, and with the combined Anrep-Moore plant in 1922. The substitution of tapered disks for the knives first used to cut the spread peat, also tended to facilitate the drying of the peat.

SAMPLING

For various reasons, which will be dealt with later, the peat spread in the field does not dry uniformly, and it is not uncommon to find a wet piece of peat alongside one that has become fairly dry, although to all appearance similar drying conditions exist in both cases. As a consequence, it is difficult to obtain a representative sample. Inasmuch as reliable data of evaporation obtained in the field-drying of peat are of importance, inquiries were made to ascertain the methods of sampling employed by other experimenters, but these inquiries did not lead to the discovery of any satisfactory method of sampling. The British Fuel Research Board of the Department of Scientific and Industrial Research, which was at that time conducting an investigation of the peat problem in Ireland, reported that the method adopted for determining the rate of evaporation from peat, was by spreading the macerated peat on boards and weighing these at intervals. This method, however, could not be employed, since the conditions are not analogous to those under which peat is dried on the bog. Evaporation is much more rapid for the peat on a dry and even board, than for peat on the drying-field in direct contact with the damp surface of the bog.

The method employed during the first season was as follows:—

A large sample of peat weighing 300 pounds and consisting of pieces of the average thickness, was taken from a week's production at the time the peat was turned. From this a sample was taken for moisture determination. The remaining bricks were placed on a staked-out plot, side by side, in a similar way to those on the drying-field, and the loss of water through evaporation was determined by weighing them from time to time. The objection to this method was found to be the difficulty in keeping the bricks of peat whole, especially after they became dry or partly dry, at which stage the edges and corners easily crumbled off, thus causing a certain inaccuracy in the results. The frequent moving of the samples from the ground to the scales is also likely to alter the drying conditions of the sample, so that it will not be precisely similar to that of the peat on the drying-field. Moreover, the method does not provide for sampling before the peat has been turned, which is done when it becomes sufficiently firm to stand handling. When it arrives at this stage, which requires two to four weeks during the early summer months, the water content of the peat has been reduced to about 70 per cent.

The following practical method was, therefore, adopted:—

On a fixed day each week, as the peat was being spread, a section of the row, uniformly spread and of average thickness, was selected and separated by a frame the width of the row (12 feet) and 6 feet long. From this section a sample was taken on a set day once a week. Every sixth brick was removed and a half-inch section cut from the middle of each. The moisture content of the sample so obtained is determined, and the rate of evaporation ascertained. The cut bricks were replaced in their respective places in the frame, and the following week another sixth of the bricks in the sample plot was removed and sampled in the same manner.

The sample thus obtained was considered fairly representative, although in many cases the drying within the frame was not uniform. Consequently, there was considerable liability to error in estimation of moisture content, due to imperfect sampling. Samples which were taken of the finished fuel as loaded on cars for shipment served as a check, and as these were found to agree fairly closely with the final results of the representative samples on the field, the method may be considered as reasonably accurate.

WATER CONTENT OF AIR-DRIED PEAT

As peat in Canada has not to date played any important part as a domestic fuel, there exist no general specifications in regard to its moisture content as sold to the consumer. It may, therefore, be of interest to know what is considered to constitute a commercial peat fuel in foreign countries. The Swedish Government which annually purchases 100,000 metric tons of peat, demands the following requirements:—

(1) Water content—maximum 30 per cent.
(2) Ash content—maximum 8 per cent.
(3) Volume—504 pounds per cubic yard.
(4) The peat to be delivered in pieces which must be hard and strong and must not crumble in handling.
(5) For larger steam plants peat containing 40 per cent water may be accepted at a reduction in price of 1·5 per cent for each unit over 30 per cent.

Owing to the experimental character of the work carried on at Alfred, and to the varying conditions of the drying-field and other causes, the peat fuel shipped by the Committee to consumers varied considerably in moisture content, ranging from 22 to 45 per cent.

Peat dried to a moisture content of 30 per cent was accepted as a standard for air-dried machine-peat fuel. Peat with this moisture content or somewhat higher, say 35 per cent, will best stand handling and transportation, and the small loss in actual heat units due to higher moisture content will be offset by the superior physical condition of the fuel. Allowing the peat to remain on the drying-field after its moisture content has been reduced below 30 per cent, is not economical, as the losses sustained from crumbling of the fuel and formation of fines will become very considerable.

In judging the dryness of peat for shipment, where facilities are not available for making moisture determinations, the fuel may be considered fit to ship when it feels heavy, rings when struck against another piece, is tough in breaking, and gives a shiny streak when rubbed against a hard object.

FACTORS AFFECTING RATE OF DRYING

High temperature, low relative humidity, wind and clear weather, each promote rapid evaporation, but the most favourable results have been recorded when the humidity has been low. Precipitation, on the other hand, is less detrimental to the drying than is ordinarily supposed, and the setback caused by rains will not much exceed the actual time during which the rainfall takes place, provided normal relative humidity occurs afterwards. From four years of observations, no evidence

has been established of peat absorbing any appreciable amount of water during the period of drying, especially while it is wet. Although from September 7th to 14th, and September 28th to October 5th, in 1920, almost continuous rains occurred, the moisture determinations showed no appreciable increase in the water contents of peat in various stages of drying on the field. On the other hand, peat which was spread on September 4th lost 23 pounds of water per 10 pounds of dry substance during the period of 10 days to September 14th, its moisture content being thereby reduced from 90 to 87 per cent.

If peat is dried by artificial agencies to complete dryness or thereabout, it will, if exposed to the atmosphere, absorb water to an extent proportionate to the humidity in the air. Experiments conducted by Dr. Sven Odën of Upsala University throw much light on this subject, and he has done extensive research work on determining what possible dryness of peat is attainable at the various pressures of the water vapour, or relative humidity. By mixing water and sulphuric acid in different proportions, he obtains atmospheres of constant humidities which are kept at constant temperatures. Samples of peat are introduced into these atmospheres, and are weighed from time to time until equilibrium is established, when evaporation ceases and the weight remains constant. The moisture content of the peat is then determined and the curve plotted. It is of interest to note from results compiled that, with an average humidity of 75 per cent, peat should dry in the open air to an average water content of about 20 per cent, and that with a relative humidity as high as 80 per cent a water content of about 30 per cent should be obtainable by air-drying. With an average humidity below 70 per cent, such as obtained from the beginning of May until the end of August during two of the four seasons of operation at Alfred, the water content of the peat should be reducible, by air-drying, to 16 to 18 per cent.

Air-drying, however, does not become so effective in practice, and in reality gives a product much higher in water content than would be expected theoretically.[1]

TURNING AND CUBING

After the peat has become dry enough to be handled, which generally requires not less than three weeks, or longer if weather conditions are unfavourable, the blocks are turned in order to expose to the air the surface which has been next to the ground. With good drying weather the fuel should become sufficiently dry to harvest in a week or ten days after being turned. In Ireland the peat blocks after being turned are stood on end in small clumps, in order to reduce the surfaces resting on the bog, and to facilitate the shedding of rain. This practice, which is called "footing," although almost essential under Irish weather conditions, has not been found necessary in Canada. In Europe it is customary to pile the partly dried peat blocks in small hollow stacks through which the air can circulate freely. This operation, which is termed "cubing," was put into practice during the first year of work on the Alfred bog, but proved expensive. Although the turning of the peat blocks was done by piecework at moderate cost, the labourers were unwilling to do the cubing on a piecework basis, and the cost by day labour was prohibitive.

[1] Prof. Sven Odën "Några Kalloidkemiska torvproblem" Teknisk Tidskrift, Vol. 50, p. 46. See also H. Hjertstedt "Om Bränntorf," (1917) p. 160.

In 1920 the peat was turned only, no cubing being done. Owing to the great variations in thickness of spreading with the Jakobson field-press, the drying of the peat was very uneven, and large quantities still contained high percentages of moisture when the bulk of the product was dry enough for shipment. This not only interfered greatly with harvesting operations, but owing to the difficulty of separating the wet blocks, led in some cases to a shipment of peat in which there was a considerable number of blocks with high water content, thereby lowering the quality of the product.

During the remaining two seasons of operation, cubing was confined to small areas where depressions occurred in the surface of the drying-field. Owing to the more uniform thickness of spreading obtained with the new type of spreader, one man was able to do all the cubing required. The cost of cubing the wet pieces was found not to exceed 4 to 5 cents per ton of total production.

It may be stated, therefore, that under Canadian climatic conditions, cubing as a general practice is not necessary, but that the cubing of wet pieces of peat and of that on spots where the drying conditions are least favourable, can be carried on to advantage.

TIME REQUIRED TO DRY PEAT

The length of time required for drying peat spread on the field naturally varies according to atmospheric conditions, time of the year, the thickness to which the peat is spread, and the condition of the drying-field. With macerated peat having 90 per cent water content, spread 5 inches thick, four weeks would appear to be the shortest period in which the peat becomes dry enough for shipment as a commercial fuel, but only a very small portion of the season's production would become dry in so short a time, and that only under most favourable weather conditions.

LENGTH OF SEASON

The length of the season during which peat fuel can be made and harvested in a saleable condition is mainly determined by the temperature. Work cannot be begun in the spring until the surface has become dry enough for spreading the excavated peat. The heavy surface covering of moss not only prevents the deep penetration of frost to the humified peat beneath, but its numerous air cells facilitate early drying of the top layers. The working-faces from which this covering has been removed may freeze to a considerable depth unless protected by holding the water at a high level in the excavation during the winter months. The presence of frost in the working-faces may, therefore, delay the commencement of excavation of peat in the spring, but with the type of excavator recommended by the Committee, this is not likely to be a serious matter, since any frozen peat in the short working-face, say 30 to 40 feet in length, can be easily removed.

The season was already well advanced when operations were begun on June 25th, 1919. During the three following seasons the dates on which the regular excavation and spreading of peat were begun were in 1920, May 15th; in 1921, May 4th; and in 1922, May 2nd. These dates are not, however, to be taken as being the earliest in those years on which manufacturing operations could have been carried on. Owing to the making of alterations in the plant, especially in 1920 when water-tube boilers were installed to replace the locomotive boilers used during the preceding season, the machines were not in readiness for operation until the dates mentioned.

The close of the operating season is regulated by the dates on which heavy frosts are likely to occur and by drying conditions during the fall months. During September and October the rate of drying slows up materially compared with that of the summer months. Wet peat when once frozen will no longer produce a satisfactory fuel, its colloidal properties and protective covering are destroyed by frost, and it dries without shrinkage to a light fibrous block which crumbles easily and readily absorbs water. The extent of injury by frost is affected by the conditions of exposure. Wet peat left spread on the field and subjected to the action of frost becomes useless for domestic fuel purposes. Peat fuel with a comparatively high water content stored under proper conditions and allowed to dry slowly in stacks, may still produce a fuel of good quality.

During the operations at Alfred the peat fuel on the drying-field became dry enough for shipment when spread on or before the following dates. In 1919, August 1st; in 1920, August 3rd; in 1921, August 19th; and in 1922, August 25th. Although the weather conditions during the first two years were comparatively unfavourable, the results recorded for those years cannot be regarded as normal for the following reasons:—

(1) In 1919 the average thickness to which the peat was spread was 6 inches as compared with 5 inches during the other seasons. This would require from 7 to 10 days longer to dry than peat spread 5 inches deep, both being exposed to the same weather conditions.

(2) With the modified Jakobson field-press employed for spreading during the first two years it was impossible to obtain uniform thickness of spreading, and large quantities of peat were spread to depths much in excess of 6 inches. With this spreader also the peat was pressed down in close contact with the bog surface which rendered the drying conditions much less favourable than with the type of spreader employed later which deposited the peat lightly on the surface.

(3) A large amount of peat fuel laid down on the field at the end of the season of 1919 in experimental work with the machines, was destroyed by frost. In the following spring, in order to clear the drying-field, this was collected and deposited along the working-trench. Having become disintegrated on drying it was again picked up by the excavator in August and mixed with raw peat from the trench. The peat spread in August, therefore, contained an admixture of frozen peat which readily absorbed moisture and so retarded drying that the peat spread during that month did not become sufficiently dry for shipment, although it remained for twelve weeks on the drying-field.

For the reasons mentioned, the dates given as the close of the seasons of 1919 and 1920 have no value or significance in determining the question as to length of season for the manufacturing of peat fuel. From the results obtained in 1921 and 1922, it may be assumed that about August 19th to August 25th may be regarded as the close of the season during which peat can be spread to a thickness of 5 inches at Alfred, with reasonable assurance of being able to harvest it as a commercial fuel. Fuel made later, if not sufficiently dry for shipment as a domestic fuel, might still be suitable for use in gas producers or for steam-raising purposes. By reducing the thickness of spreading to 4 inches, another week or ten days might be added to the period of active production. For practical purposes, therefore, the season for manufacture of air-dried machine-peat fuel at Alfred may be considered as embracing the months of May, June, July, and August, being a period of about 100 days, exclusive of Sundays.

THICKNESS OF SPREADING

In 1921 a series of spreadings of experimental plots were made to ascertain the effect on the length of time of drying of spreading raw peat to different thicknesses.

On June 10th three plots were spread with macerated peat to depths of 4, 5, and 6 inches, respectively. Peat spread 4 inches deep dried to 30 per cent in 20 days, spread 5 inches deep dried to 32 per cent in 28 days, and spread 6 inches deep dried to 34 per cent in 39 days. A second experimental spreading was made on July 15th. Peat spread 4 inches dried to 30 per cent in 35 days, spread 5 inches deep dried to 33 per cent in 42 days, and spread 6 inches deep dried to 48 per cent in 60 days. Weather conditions continued favourable or even improved during the period of drying of the peat spread in June. In the case of the second spreading, however, after the peat spread 5 inches deep had dried, the remaining peat which had been spread to 6 inches was subjected to much lower temperature and more unfavourable drying conditions generally. Spreading 6 inches deep later than July 15th should not be considered. Additional experimental spreadings were made on July 29th and August 19th, but these were of 4 and 5 inches thicknesses only. Peat spread 4 inches thick on July 29th dried to 30 per cent moisture in 42 days, whereas peat spread 5 inches thick on the same date dried to 32 per cent in 50 days. Peat spread 4 inches thick on August 19th dried to 35 per cent in 50 days, and peat spread 5 inches thick dried to 40 per cent in 57 days. The results above shown for the various spreadings of 5 inches thickness correspond fairly well with results of spreading on the field as shown by the curves accompanying this report. In the case of the spreading made on July 29th, the result shown is somewhat better than that indicated by the curve, but the variation is not large and may be due to a more favourable condition of the ground where the experimental plots were spread than the drying-field as a whole. The results indicate the marked advantage of reducing the thickness of spreading to 4 inches toward the end of the season.

OBSERVATIONS ON WEATHER CONDITIONS

The four seasons during which meteorological observations were recorded at Alfred presented widely varying atmospheric conditions, and the experience gained in drying of peat during the period of observation should be applicable to almost any weather conditions likely to occur in that locality.

In accordance with advice from the Meteorological Service (Toronto) the average of the records taken for Montreal during a period of forty-five years, has been accepted as normal for conditions at Alfred, and is used as a basis of comparison in this report.

1919: This being the opening season of the investigation by the Peat Committee, and the plant not being in readiness at an earlier date, operations were not commenced until June 25th. As the observations were begun concurrently with the work of manufacture, the records for that year are incomplete. During the period covered by the operations weather conditions on the whole were adverse to the successful manufacture of peat fuel. The average precipitation during the months of June, July, and October was considerably above normal. The precipitation recorded for September at Alfred was lower than the average, but rains occurred very frequently, and with high relative humidity, seriously retarded drying of the peat. As indicated by the curves, the evaporation during that month was almost negligible. Unusually low minimum temperatures were recorded for September, in consequence of which a large amount of the peat spread on the drying-grounds was frozen while still wet and so became unfit for use as fuel.

1920: Meteorological observations were recorded as early as April 1st. It had been hoped to commence operations at the earliest possible date, in order to ensure as long a peat-manufacturing season as possible, but owing to alterations being made, the machines were not ready for operation until the second week in May. The season was very backward and owing to temperatures considerably below normal during April and the early part of May with unusually low minimum temperatures, the frost remained in the ground very late.

Generally speaking, weather conditions during the summer were not favourable. During the month of April both precipitation and humidity were considerably above normal, and the temperature below the average. May was more favourable, especially during the latter part of the month. The precipitation was unusually low, humidity only slightly above normal, and the temperature, especially during the latter part of the month, high. June, which should be the most favourable month in the year for long days and warm weather, was rather unfavourable for drying, the weather being damp and cold, the relative humidity unusually high, and the average temperature five degrees lower than normal, with only slight variations from week to week. The precipitation was three-quarters of an inch less than normal, but nevertheless the sky was cloudy with frequent rainfalls, and there was little sunshine. July was even more unfavourable than the preceding month, owing to prolonged and very heavy rains and continued high humidity. In addition the temperature was below normal. The weather conditions for August were practically normal, but September was most unfavourable for drying peat. Although the average temperature for that month was three degrees above normal, the precipitation was

very heavy with long continued rainfalls and consequently high relative humidity. Especially during the second week of September the relative humidity rose to unusually high figures, and no drying took place. The nights were misty, and the dew at times remained on the ground for several days. The atmospheric conditions in October were very favourable, although the records for the month show a precipitation above normal. This was due to some unusually heavy rainfalls of comparatively short duration occurring during the first days of the month, while for the balance of the month the weather was dry and clear with high temperature and humidity below normal. During the first two weeks of November the atmospheric conditions were about normal. The evaporation during this month, however, is as a rule negligible and no drying can be counted upon.

1921: The weather conditions from the beginning to the end of the season were very favourable for drying peat. The temperature remained above normal for almost the entire season, increasing continuously until the peak was reached on July 8th, after which, with some variations, the weather continued warm throughout the drying season, a minimum average temperature lower than 60° F. being recorded for the first time during the third week of September. Humidity remained below normal for May and June, increased slightly above normal for July and August, and became somewhat higher for September and October. The average relative humidity registered was below 70 per cent until July, during which month the highest average record was 82 per cent for the week ending July 15th, after which, with two or three variations, it remained at 75 per cent. The low humidity during the earlier part of the season was without a doubt the reason for the very rapid drying during this period. Rainfalls were very light, and considerably below the average, especially up to July 8th. During the following week rainfalls occurred on six consecutive days, and little evaporation took place. From that time there was a marked slackening in the rate of evaporation.

1922: The season on the whole was very favourable, the temperature during May, June, July, and August being about normal, and for September and October considerably above normal, although no prolonged period of very warm weather was recorded. Humidity was found to be about normal with, as might be expected, a few exceptions, as for example during the week ending June 23rd, when the average relative humidity rose to 86 per cent. Precipitation was below normal throughout the season. Evaporation was even, and if not so rapid as the year before, continued much later in the season than any preceding year.

INTERPRETATION OF CURVES

A series of curves, has been plotted to show the rate of field-drying of peat fuel at Alfred during the four years of operation, as determined by weekly sampling. (Figures 36, 38, 40, and 42.) The ordinates show the moisture content of the peat at various stages of drying by percentages, and the dates of sampling are indicated by the abscissae. The rainfall during each week is shown in tenths of inches. The weekly averages of temperature and humidity are also plotted. Further details as to weather conditions are shown in the accompanying tables. The curves in Figures 37, 39, 41, and 43 show the rate of removal of water by evaporation expressed in pounds of water per 10 pounds of dry peat substance.

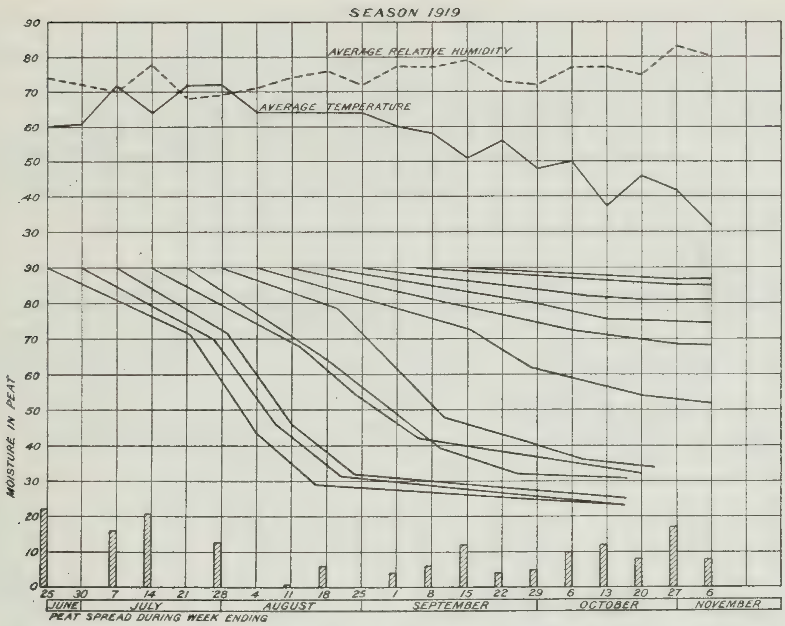

FIGURE 36. Curves showing moisture in peat spread during the season of 1919 at different stages of drying

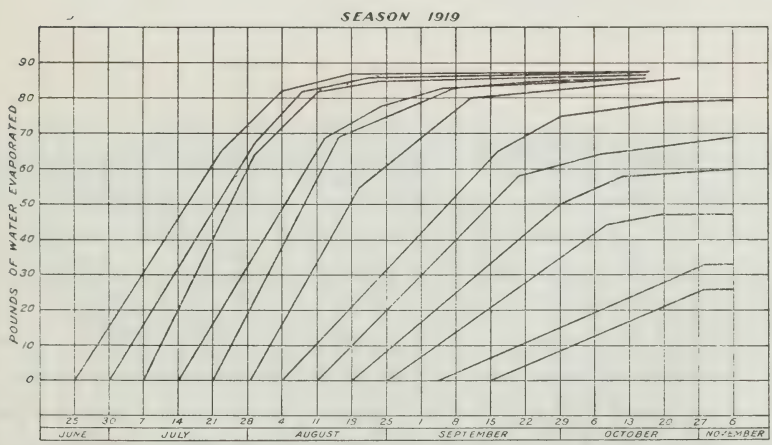

FIGURE 37. Curves showing rate of evaporation from peat spread during the season of 1919

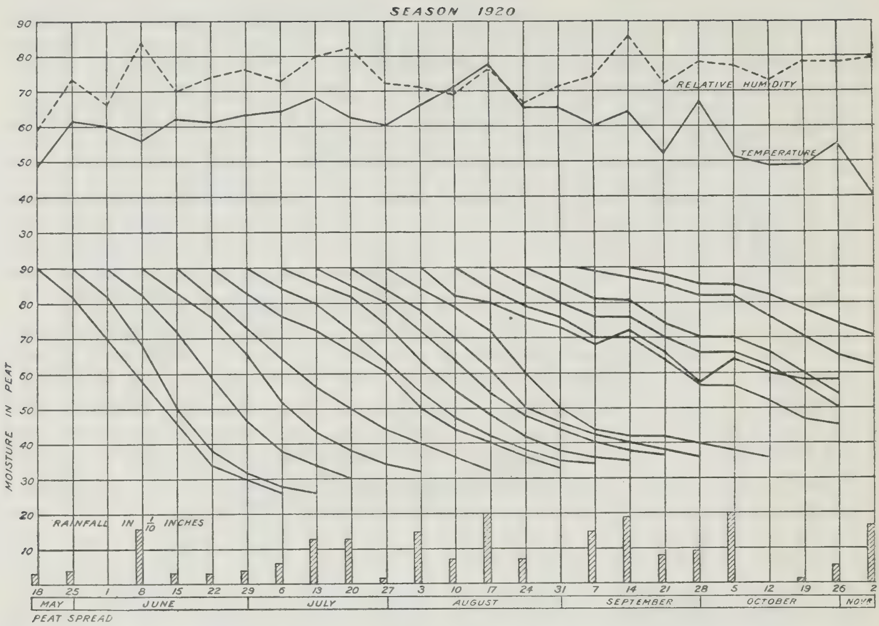

FIGURE 38. Curves showing moisture in peat spread during season of 1920 at different stages of drying

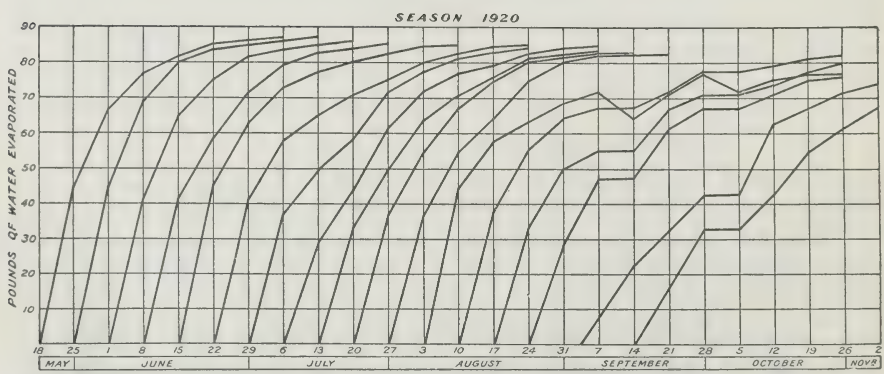

FIGURE 39. Curves showing rate of evaporation from peat spread during season of 1920

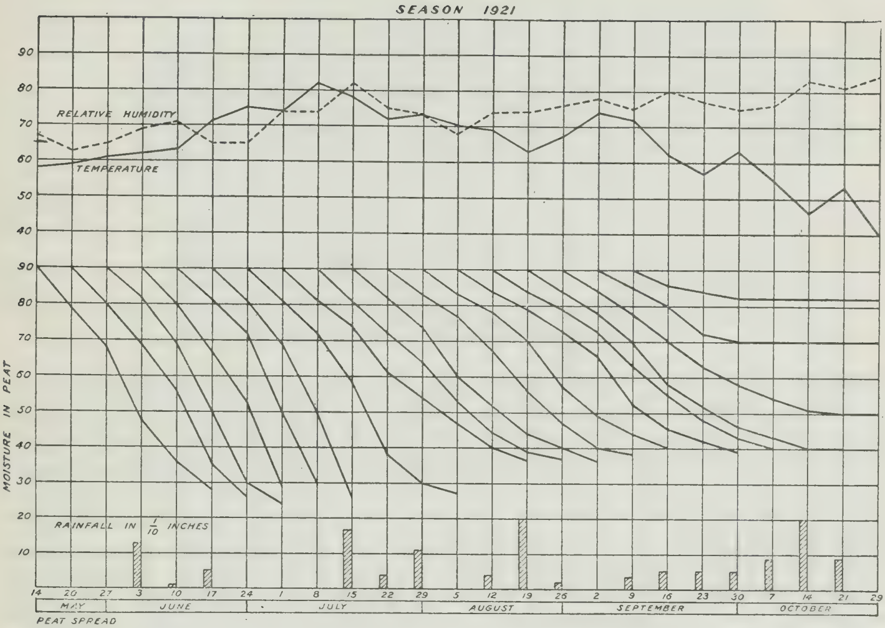

FIGURE 40. Curves showing moisture in peat spread during season of 1921 at different stages of drying

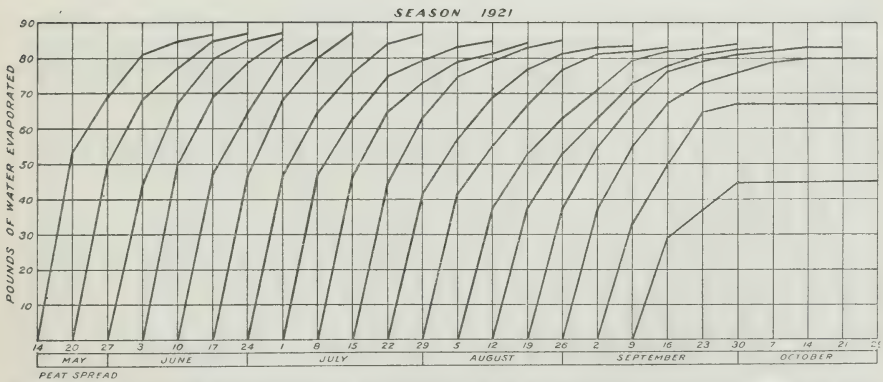

FIGURE 41. Curves showing rate of evaporation from peat spread during the season of 1921

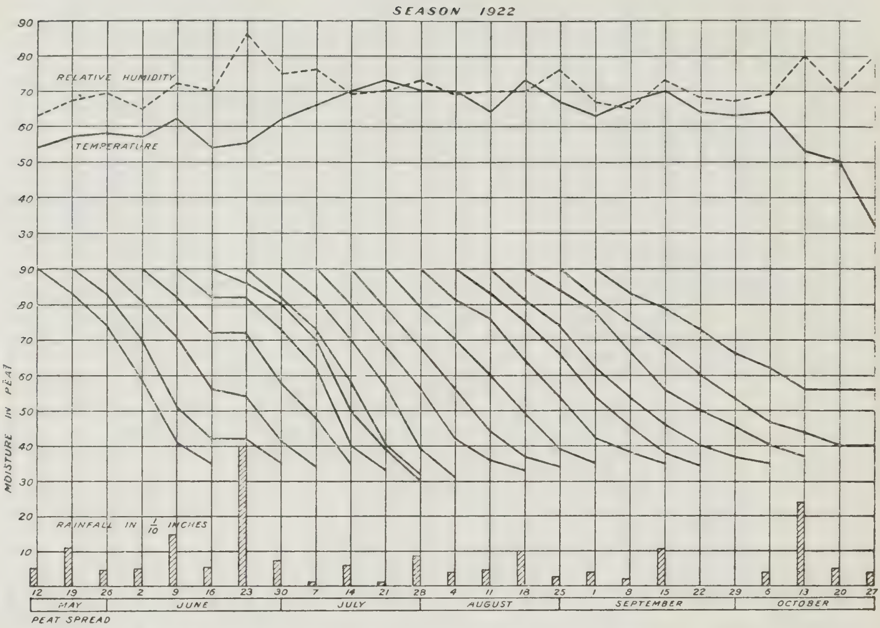

FIGURE 42. Curves showing moisture in peat spread during season of 1922 at different stages of drying

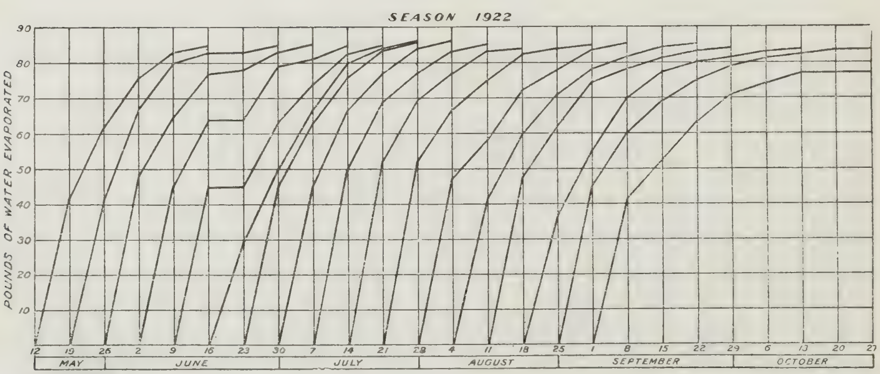

FIGURE 43. Curves showing rate of evaporation from peat spread during season of 1922

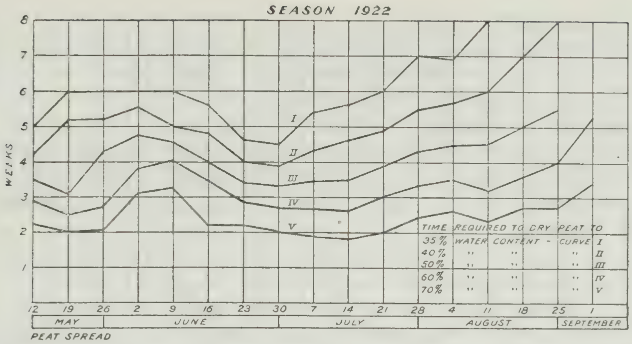

FIGURE 44. Curves showing time required to dry peat to various moisture contents during the season of 1922

It will be noted that drying conditions were most uniform in 1921, especially during the early part of the season, and peat spread before the last week in June became dry in four to five weeks. During the corresponding period in 1919 no peat was spread, as operations were not begun until June 25th of that year. In the early part of 1920 the average temperature was several degrees lower, and the average humidity several degrees higher, and the rainfalls were more frequent and precipitation much greater than in 1921. The time required for drying of peat varied from four to nine weeks. In 1922 the rate of drying was irregular. During the week, June 15th to 23rd, there was exceptionally heavy rainfall (4 inches) accompanied by low average temperature and very high relative humidity, which retarded drying of the peat on the ground. It is interesting to note, however, that notwithstanding these conditions, peat spread on the ground up to June 23rd became dry in five weeks, as compared with four to five weeks under very favourable drying conditions in the early part of 1921. These results go to form the opinion that the delay caused by actual precipitation does not extend very much beyond the period of the rainfall.

Peat laid on the ground during the month of July required a longer period for drying. Peat spread in July, 1921, dried at a fairly uniform rate in seven to eight weeks. For the same period in 1920 an average of nine weeks was required for drying. Peat spread during the latter part of the month was subjected to very unfavourable drying conditions. Owing to continued rains in the early part of September with low temperatures and high relative humidity, peat spread during the week ending July 27th required two additional weeks to dry. In 1922 peat spread in July dried in five to seven weeks. The rate of drying was very uniform and with evenly high temperature and moderate humidity, the precipitation being comparatively small. Peat spread in July of 1919 required from eight to ten weeks to become dry. However, for reasons already stated, the results for 1919 cannot be fairly compared with those for the other years. The different method of spreading employed, and the greater depth to which the peat was spread, rendered the conditions during that year altogether different. It may be noted also that the method of sampling employed in 1919 was not the same as for the three later years.

Peat spread during August up to the 19th, 1921, dried to about 40 per cent moisture content in eight weeks. After the end of the first week in October practically no drying occurred. Peat spread on August 26th dried to 50 per cent moisture content in seven weeks. Peat fuel with this moisture content, if properly taken care of, becomes available for use. The rate of drying towards the close of the 1920 season was very slow. Weather conditions were very adverse with heavy rains for five weeks, and high humidity and low temperature. Peat spread during the week of August 10th dried to 45 per cent moisture content in eleven weeks, and that spread on August 17th dried to 50 per cent in the same length of time. The curve for peat spread on August 3rd requires special explanation. The peat being excavated at that time, from which the sample was taken, contained a considerable amount of disintegrated frozen peat which had been left on the ground near the working-trench from the preceding season. The absorption of water by this frozen peat greatly retarded drying, and it will be noted that in the weeks September 7th to 14th, and September 28th to October 5th, there was an actual increase of moisture content as a result of heavy rains. Drying conditions continued favourable to the end of the season in 1922 and peat dried in seven to eight weeks. Peat spread on August 25th dried to 40 per cent in eight weeks, and that spread on September 2nd to 56 per cent in six weeks. Weather conditions and rate of drying were uniformly favourable up to the end of the first week in October, when a sharp dip in temperature occurred with increased humidity and heavy rains following.

Figure 44 has been compiled from data contained in the curves and table for 1922, and shows the time required for drying peat to certain given percentages of moisture content at different times of spreading, e.g., peat spread on June 30th, 1922, dried to 70 per cent moisture content in two weeks, to 60 per cent in 2·7 weeks, to 50 per cent in 3·3 weeks, to 40 per cent in 3·9 weeks, and 35 per cent in 4·5 weeks.

CHEMISTRY OF PEAT

The determination by ultimate analyses of the amount of carbon and hydrogen present in a sample of peat, and even the estimation of ash present gives little enlightenment as to the quality of peat for its various technical uses. Of more value are approximate analyses and the determination of the calorific value of the dried peat, but the main factor in determining the classification of peat is the estimation of the humus substances which it contains and which have been formed during the process of humification.

Several methods for determining the degree of humification of peat have been devised, none of which, however, is admittedly applicable with any great degree of accuracy. As very little work has been done along these lines, and no standard method has been accepted, it would hardly be of interest to describe more than the one which is considered most serviceable. This method has been worked out by Odën and Mellin, who obtained fairly concordant results from independent analyses.

The difficulty has been to extract all the humified materials and to determine these independently of pectin substances and vegetable proteins which also are extracted during the process of digestion. This difficulty has been overcome by the use of the colorimeter, but here the difficulty encountered has been to obtain a suitable substance for colorimetric

comparison. "Acidum humicum" made by E. Marck proved to be too variable in its composition. A considerable improvement and very much better results were obtained by using synthetic humic acid made from hydroquinone in accordance with the Eller method.

The process of humification produces humic acid, which is soluble in alkali solution, forming a strongly-coloured brown liquid. A comparison of this with a standard solution made with synthetic humic acid, is the method which has been worked out by Odën and Mellin for determination of humic acid.

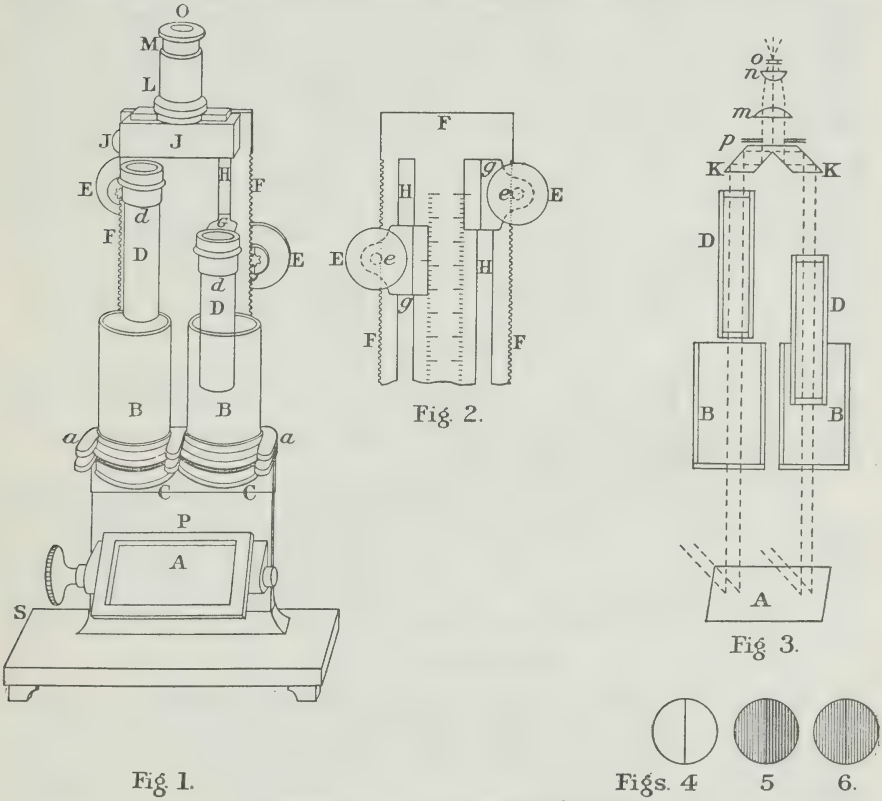

Figure 45. The Dubosq colorimeter

COLORIMETER

The Dubosq colorimeter (Figure 45) is well suited for these determinations.

Figure 1 represents the apparatus.

Figure 2 represents a back view, and shows the divisions and the vernier.

Figure 3 shows the path of light inside the instruments.

The diffused light from a lamp or a monochromatic burner, after being reflected into mirror A, is separated into two beams which penetrate respectively into two tubes BB. The right beam is reflected twice in the right half of prism K, penetrating into the eyepiece; it therefore affects only the right half of the field; the left beam affects only the left side of the field.

Figures 4, 5, and 6, respectively, show the appearance of diagram seen through the eyepiece when the apparatus is regulated to zero in use and when equality of tones have been obtained.

No bright light is needed; it is sometimes better to place before the mirror a piece of ground glass.

For use the instrument is set to face a source of light and mirror A is set at the proper angle to reflect the light upward through the tubes BB. The standard solution is placed in the left tube, and the liquid to be compared, in the right. The right tube D is now lowered until it reaches what appears to be the most convenient point for estimation which will depend on the colour of the liquids; now note the divisions on scale corresponding to the standard liquid. Lower the tubes DD until they touch the bottom of BB and the vernier g marks zero. Look through O and then gradually move the apparatus until both fields are equally illuminated. Now move screws E till equality of tone is produced. For two liquids the colour is inversely proportional to the depth of the column of liquid traversed by the light, and proportional to the quantity of dissolved matter.

$$\frac{\text{Colour of liquid}}{\text{Colour of standard}} \qquad \frac{\text{light of standard}}{\text{light of liquid}}$$

STANDARD SOLUTION

Synthetic humic acid is prepared by oxidizing hydroquinone in an alkali solution with potassium persulphate, after which the humus substance formed is precipitated by hydrochloric acid and well washed with acid water containing sodium chloride.

The standard solution is prepared as follows: 0·1 gramme of humic acid prepared from hydroquinone dissolved in 25 c.c. of a sodium hydrate solution and diluted to 250 c.c. From this solution 15 c.c. is pipetted off and made up to 100 c.c. This is used as the standard solution for colour comparison. The stability of the standard solution is of comparatively short durability and a fresh solution must be made up at least once a month.

METHOD OF ANALYSIS

Five to ten grammes of ground peat is suspended in 300 c.c. of a 10 per cent solution of sodium hydrate. The mixture is brought to boiling and the digestion continued for 30 minutes, and afterwards diluted to 1,000 c.c. After 24 hours a suitable amount of the supernatant liquid is pipetted off for colorimetric comparison.

This method as compared with any other known method gives close results, but nevertheless does not claim accuracy closer than within 5 per cent limits.

DETERMINATION OF WATER

For determination of water content a large quantity of peat is weighed out and dried at 110° C. until constant weight is obtained. In the case of the samples collected in the field, generally 200 to 400 grammes are weighed out, the amount depending on the moisture in the peat, the larger amount being taken for the very wet samples. The time required for drying is 12 hours. The method may be considered to give sufficient accuracy for practical purposes, although it can hardly be recommended as an accurate determination.

Experiments on smaller amounts of substance—3 to 10 grammes—prove that it is very difficult to obtain a constant weight. If the drying is continued longer than 12 hours at 110° C. a loss of weight will be noticed for a considerable time—two to three weeks and often longer—after which an increase in weight may be noted. On the other hand, after the rapid evaporation during the first 10 hours, no appreciable decrease in weight is noted, when weighed again two hours later. It may, therefore, be accepted that during the first period of 10 to 12 hours all of the water, free or colloidal, is eliminated through evaporation, but after that a slow chemical reaction takes place, probably of the same character as the humification (H and OH react forming water) or through oxidation of organic substances. The distinct odour of peat at 110° C. in the drying-oven would indicate that a gas is being evolved through destructive distillation or other chemical reaction.

The results obtained by oven drying depend upon the completeness of the removal of the water content of the sample. The lack of homogeneity of the sample may introduce serious errors in any moisture determination, but this factor can be overcome to some extent by using relatively large samples. There is also the possibility of sealing in of the water by varnish-like films. To what extent these factors affect the results have as yet not been determined, but far more important factors are the results of oxidation during heating and loss by volatilization of substances other than water.

DIRECT METHOD OF DETERMINATION

The following method has the advantage of being a direct determination of water. It gives very accurate and concordant results, and the determination can be accomplished in less than an hour.

Introduce into a 200 c.c. pyrex Soxlet flask a sufficient known weight of the substance to give not more than 5 c.c. water. Add to this either 150 c.c. of a mixture of amyl acetate and amyl valeriate in proportion 5:1, or toluene. If the solution is liable to bump, add enough dry sand to cover the bottom of the flask. Attach flask to condenser with the discharge end of the latter connected to adapter placed in a graduated tube or burette. Add water up to the lowest division of the burette. Distil slowly (about two drops per second), and continue until at least 50 c.c. has been distilled over. Allow the burette to stand and take reading of increase in water content, each c.c. at 60° F. corresponding to 1 gramme of water. The burette is calibrated in tenths and the column can be read to hundredths with reasonable accuracy. If any drops of water adhere to the sides of the burette they can be forced down by a rubber band wrapped around a copper wire.

It is necessary to have the condenser and receiving-tube chemically clean in order to prevent an undue quantity of water adhering to the sides of the receiving-tube. Clean with a mixture of chromic and sulphuric acid, rinse with alcohol and dry in oven.

Comparative results of this and the drying-oven method show marked difference.

Peat dried at 110° C. for 12 hours yielded 50·50 per cent water.

Same sample using distilling method yielded 48·25 per cent water.

It is well to run a blank determination to ascertain absence of water in the reagents.

Weather Conditions, 1919

Average for Week Ending	June		July				August				September					October				Nov.
	25	30	7	14	21	28	4	11	18	25	1	8	15	22	29	6	13	20	27	6
Rainfall .... inches	2·20	none	1·60	2·15	none	1·25	none	0·20	0·60	none	0·40	0·60	1·20	0·40	0·50	1·00	1·20	0·60	1·75	0·60
Humidity	74	72	70	78	68	69	71	74	76	72	77	77	79	73	72	77	77	75	83	80
Temperature, average	60	61	71	64	72	72	64	64	64	64	60	58	51	56	48	50	37	46	42	32
" average max.	70	72	88	79	86	84	77	76	78	77	70	70	61	68	70	55	57	50	50	43
" average min.	50	51	60	55	61	60	54	56	54	59	52	50	39	42	34	36	29	29	29	20
" max.	80	84	92	92	96	92	84	82	84	84	72	79	65	78	70	64	70	66	61	50
" min.	39	40	51	51	56	54	51	44	50	56	50	30	26	27	22	29	17	19	20	18
Barom. press., average min.	30·0	30·2	30·1	30·0	30·0	29·9	29·8	30·0	30·3	29·9	29·8	30·1	30·0	29·9	30·0	30·0	30·0	30·2	30·0	30·2
high	30·1	30·5	30·4	30·3	30·2	30·1	30·0	30·2	30·4	30·0	30·0	30·2	30·1	30·2	30·5	30·4	30·4	30·4	30·3	30·5
low	30·0	29·8	29·4	29·4	29·7	29·8	29·7	29·4	29·9	29·8	29·7	29·9	29·8	29·7	29·5	29·8	29·9	29·9	29·7	29·8

Weather Conditions, 1920

Average for Week Ending	April				May				June					July			
	6	13	20	27	4	11	18	25	1	8	15	22	29	6	13	20	27
Rainfall .... inches	0·95	1·26	0·45	0·80	0·80	0·11	0·11	0·20	0·00	1·60	0·40	0·30	0·40	0·60	1·30	1·30	0·05
Humidity	66	72	60	56	76	62	59	77	66	85	70	74	76	73	80	82	72
Temperature, average	36	38	42	47	49	46	49	61	60	56	62	61	63	64	69	62	60
" average max	48	49	51	55	65	64	64	75	79	73	81	74	78	72	78	75	77
" average min	29	31	34	35	37	32	37	51	49	48	51	51	52	53	59	52	48
" max	50	58	66	71	66	72	85	81	83	88	86	84	88	83	85	98	84
" min	24	26	28	28	32	25	30	45	39	38	45	41	43	44	50	42	41
Barom. press., average	29·50	29·85	29·65	29·80	29·70	30·00	30·15	30·00	29·95	29·90	29·85	29·80	30·10	29·80	30·00	29·85	29·90
" highest	30·00	30·00	30·10	30·15	30·05	30·30	30·40	30·15	30·10	30·20	30·10	30·15	30·35	29·95	30·25	30·10	30·15
" lowest	29·50	29·10	29·40	29·40	29·45	29·65	29·85	29·90	29·80	29·75	29·70	29·60	29·65	29·50	29·60	29·75	29·50

Weather Conditions, 1920

—	August					September				October				November	
	3	10	17	24	31	7	14	21	28	5	12	19	26	2	9
Rainfall .... inches	1·50	0·70	2·00	0·70	0·00	1·50	1·83	0·80	0·95	2·00	0·00	0·30	0·45	1·65	1·30
Humidity	71	69	77	66	71	74	87	72	78	77	73	78	78	79	79
Temperature, average	66	71	78	65	65	60	64	52	67	51	49	49	46	41	34
" average max	78	86	84	81	86	75	72	66	82	67	66	69	64	48	40
" average min	52	56	64	50	55	46	53	39	54	41	35	42	41	33	27
" max	85	94	92	86	93	80	80	85	92	78	75	74	72	61	48
" min	44	37	59	44	51	36	46	26	40	32	30	28	28	21	21
Barom. press., average	29·95	30·10	30·00	30·15	30·10	30·00	29·90	30·00	30·10	29·75	30·05	30·15	30·05	29·85	30·00
" highest	30·20	30·30	30·05	30·45	30·40	30·15	30·05	30·20	30·35	30·00	30·25	30·45	30·25	30·10	30·45
" lowest	29·65	29·80	29·90	29·75	29·65	29·40	29·65	29·65	29·80	29·40	29·90	29·95	29·85	29·55	29·40

Weather Conditions, 1920

—	Montreal Averages of 45 Years								Alfred, 1920							
	April	May	June	July	Aug.	Sept.	Oct.	Nov.	April	May	June	July	Aug.	Sept.	Oct.	Nov. 2 weeks
	2·33	3·14	3·49	3·71	3·43	3·51	3·28	3·48	3·06	0·60	2·75	4·66	3·40	5·08	3·95	1·60
Humidity	66	65	70	71	72	75	78	79	64	68	74	77	71	78	76	79
Temperature (mean daily highest)	49	64	73	78	75	66	53	39	51	70	79	75	83	76	67	38
Temperature (mean daily lowest	33	46	56	61	59	51	40	27	32	43	50	54	56	48	40	30
Mean	42	55	65	66	66	58	46	33	38	51	60	64	69	61	51	44
Barometric pressure mean	29·96	29·93	29·91	29·90	29·95	30·02	30·02	30·00	29·70	29·93	29·87	29·89	30·10	30·00	30·00	29·93

Weather Conditions, 1921

—	April			May				June					July				August				September					October			
	15	22	29	6	13	20	27	3	10	17	24	30	8	15	22	29	5	12	19	26	2	9	16	23	30	7	14	21	29
Rainfall, inches	0·04	1·76	0·67	none	0·21	none	0·05	1·30	0·10	0·51	none	none	none	1·75	0·40	1·05	none	0·40	2·00	0·20	none	0·35	0·50	0·50	0·50	0·85	2·00	0·85	0·80
Humidity	74	76	72	65	67	63	65	69	71	65	65	74	74	82	75	73	68	74	74	76	78	75	80	77	75	76	83	81	84
Temperature, average	44	47	52	56	58	59	61	62	63	71	75·5	74	82	78	72	73	70	69	63	67	74	72	62	57	63	55	46	53	40
" average max	54	54	63	66	68	66	72	76	78·5	79·8	92	89·5	96	96	86	91	82	80	78	81	85	82	77	70	74	63·5	54	65	52
" average min	35	34	45	47	46	48	51	57	47	55	58	60	68	69	59	63	50	59	54	51	57	51	55	43	49	48	41	46	35
" max	64	68	75	67	78	90	89	85	85	87	97	90	103	100	93	94	86	86	81	85	96	90	90	76	82	69	60	70	62
" min	25	26	39	39	39	33	40	46	38	42	48	50	62	66	50	58	42	46	46	44	42	40	35	37	43	42	30	40	26
Barom. press., average	29·8	29·7	29·9	29·7	29·8	30·0	29·9	29·8	29·8	29·7	29·7	29·8	29·9	29·9	29·9	30·0	29·8	30·0	29·8	30·1	30·0	29·9	29·9	29·8	29·9	29·6	29·7	29·8	....
high	30·1	30·0	30·0	29·9	30·1	30·2	30·1	29·9	30·1	29·9	29·8	30·0	30·0	30·0	30·2	30·1	30·1	30·1	30·0	30·2	30·1	30·0	30·1	30·3	30·0	29·8	30·1	30·0	....
low	29·5	29·6	29·6	29·7	29·6	29·7	29·6	29·5	29·7	29·4	29·6	29·6	29·8	29·8	29·7	29·8	29·7	30·0	29·6	29·7	29·8	29·8	29·9	29·5	29·2	29·4	29·4	29·3	....

Weather Conditions, 1922

Average for Week Ending	April	May				June					July				August				September					October				Nov.
	28	5	12	19	26	2	9	16	23	30	7	14	21	28	4	11	18	25	1	8	15	22	29	6	13	20	27	3
Rainfall, inches	0·20	0·70	0·51	1·25	0·45	0·50	1·45	0·55	3·85	0·75	0·10	0·60	0·10	0·85	0·40	0·45	1·00	0·15	0·40	0·20	1·10	none	none	0·40	2·40	0·50	0·40	0·50
Humidity	66	67	63	67	69	65	72	70	86	75	76	69	70	73	69	70	70	76	67	65	73	68	67	69	80	70	80	80
Temperature, average	47	47	54	57	58	57	62	56	57	62	66	70	73	70	70	64	73	67	63	67	70	64	63	64	53	50	32	37
" average max	55	58	59	67	67	71	72	63	63	72	72	80	83	79	82	73	85	77	77	80	78	72	74	77	57	58	42	47
" average min	31	37	41	44	47	45	54	48	53	53	54	59	60	60	50	50	62	61	52	55	47	47	48	52	48	40	26	27
" max	66	68	71	73	74	76	78	71	73	76	78	83	85	86	87	79	90	85	82	87	87	78	80	83	69	69	48	58
" min	27	29	37	38	43	39	48	41	51	46	51	53	53	56	51	46	57	51	48	50	46	30	30	40	35	22	13	23
Barom. press., average	31·4	30·3	30·0	30·1	30·2	30·3	30·1	30·0	30·0	30·2	30·2	30·3	30·4	30·0	29·9	29·9	30·1	30·0	29·9	30·0	30·0	30·4	30·2	30·0	29·8	30·0	30·0	30·0
high	30·7	30·6	30·5	30·2	30·7	30·7	30·5	30·5	30·4	30·5	30·5	30·6	30·5	30·5	30·0	30·4	30·5	30·1	30·1	30·4	30·4	30·6	30·5	30·3	30·6	30·6	30·3	30·2
low	29·9	29·9	29·5	29·4	29·3	30·3	30·0	29·4	29·9	30·0	30·0	30·0	30·0	30·0	29·7	29·4	29·6	29·5	29·3	29·7	29·7	30·1	29·7	29·6	29·4	29·4	29·7	29·7

APPENDIX B

REPORT ON THE RELATION OF THE MACERATION TO THE DRYING QUALITIES OF PEAT

R. E. Gilmore[1]

Superintendent Fuel Testing Laboratories

Several series of experiments were made during the past year on the relation of mechanical and chemical treatment to the air-drying qualities of wet peat. These experiments as originally planned are as yet incomplete. The following provisional report and conclusions may, however, be made.

INDEX OF STOCK SAMPLES OF WET PEAT USED

Io Wet peat as dug from the bog at Alfred.
I Wet peat (Io) mixed in lignite binder-mixer for 30 minutes.
II Wet peat (Io) mixed 5 minutes at laboratory.
III Macerated wet peat from conveyer belt, i.e., from Jeffrey hammer mill shredder to drying-field at Alfred, Ont.
III A Wet peat III further macerated in iron ball mill in laboratory.
IV Jeffrey hammer mill macerated peat same as III.

A. EFFECT OF MACERATION ON DRAINING QUALITIES

Three samples of wet peat were drained in three different glass cylinders open at both ends. The columns of wet peat thus drained were 36 inches long by 2½ inches diameter. At the lower ends were placed glass beads and wire gauze which rested on beakers, the double purpose of which was to hold up the column of peat and at the same time allow it to drain into the beaker. Inverted beakers were placed over the tops of the cylinders to prevent evaporation.

The three samples of peat used were:—

Io Wet peat as dug from bog—with no mixing.
I Wet peat mixed in laboratory for 30 minutes.
IV Macerated wet peat from conveyer belt at Alfred.

[1]Through the courtesy of the Mines Branch of the Department of Mines the services of R.E. Gilmore were loaned to the Peat Committee to conduct this investigation.

These were allowed to stand for 2 months at room temperature, and the drainage noted as follows:—

Results	Drainage: inches of water in 400 c.c. pyrex beakers		
	Io	I	IV
Sept. 30. Experiment started			
Oct. 2— 2 days	4	7/16	11/16
Oct. 5— 5 "	5½	10/16	1
Oct. 9— 9 "	5 5/8	12/16	1 3/16
Oct. 16—16 "	5 15/16	14/16	1 8/16
Oct. 25—25 "	5 14/16	15/16	1 14/16
Nov. 20—50 "	5 13/16	1	2 8/16
Dec. 1—61 "	5 12/16	1	2 10/16
Equivalent in c.c. of water	546	95	250
Rate of drainage	fast at first, slow at end	slow	slow at first, faster at end
Moisture content of peat—			
before drainage %	90·0	91·5	88·5
after drainage—top %	83·6	89·8	86·2
after drainage—bottom %	88·8	85·6	85·3
Apparent specific gravity of peat moulded in small dishes and air-dried—			
top	0·65	0·92	1·00
bottom	0·60	0·90	0·98

INTERPRETATION OF RESULTS

(a) The draining qualities of wet peat vary according to the degree of maceration—the more the peat is macerated the less will it respond to losing its water content by natural drainage.

(b) The moisture content of wet peat as dug from the bog after draining for 2 months was roughly 84 per cent on top and 89 per cent at the bottom.

(c) The wet peat mixed in laboratory for 30 minutes varied from machine macerated peat from Alfred in that the drainage from the former was uniformly slow but the drainage from the latter was slow at first and faster toward the end of the two-month period.

(d) The higher apparent specific gravity of IV, i.e., the machine macerated peat indicates that the maceration was of a nature different from that of I, viz., peat simply mixed.

B. RELATION OF MOISTURE CONTENT OF WET PEAT TO ITS MOULDING AND AIR-DRYING QUALITIES

Three 4,000-gramme lots of wet peat (90 per cent H_2O), mixed in laboratory for 30 minutes, were air-dried slowly under room conditions to different moisture contents. These samples were mixed thoroughly at intervals during the drying period of fifteen days. Their moulding qualities were then tested.

	(a)	(b)	(c)
Moisture content	81 per cent	78 per cent	65 per cent
Moulding qualities	fair with hand pressure	poor with hand pressure	too dry to mould

Water was added to (c) to raise the moisture content up to 75 per cent and a briquette was moulded by hand pressure.

The three briquettes were placed alongside four others made from wet peat I and Io, and after air-drying, the condition and apparent specific gravity were noted.

—	I	I (a)	I (b)	I (c)	I	I	Io
Wt. of sample (grms.)	1,046	1,161	1,017	513	485	487	509
Moisture, per cent	90	81	78	75	90	90	90
Moisture air-dried, per cent	13·6	16·4	15·2	13·5	15·0	14·7	11·1
Apparent sp. gr	0·89	0·85	0·74	0·78	0·91	0·90	0·47
Condition of air-dried brick	easy to break	hard to break	fair	crumbled easily	same as I (b)	hard to break	hard to break
Rate of drying	fairly rapid	slower than I	slower than I (a)	....	....	....	....
Shrinkage by drying	63%	18%	8%	....	....	....	....

Size of mould used for I, I (a) and I (b) = 6 by 3 by 2 inches.

INTERPRETATION OF RESULTS

Macerated peat below about 80 per cent moisture did not mould readily as per regular air-drying practice for wet peat. At this moisture content, however, it did form a good briquette by hand pressure, and a fair briquette was obtained at a moisture content as low as about 75 per cent. The apparent density of the air-dried briquette decreased with the moisture content of the material moulded.

C. RELATION OF DEGREE OF MACERATION TO DRYING QUALITIES

(1) Air-Drying of Wet Peat Moulded in Cement Forms

Three series of drying experiments were run on three different raw wet peat samples, viz., I, II, and III, portions of which in turn were macerated in laboratory iron ball mill for 5, 15, 30, 60, and 120 minutes respectively. The three raw peat samples were as follows:—

I—Raw wet peat from box mixed 30 minutes in laboratory.

II—Raw wet peat from bog mixed 5 minutes in laboratory.

III—Macerated wet peat from conveyer belt at Alfred, Ont.

Six samples in each series were moulded in brass cement moulds—3 briquettes to each mould. After allowing to stand for three to five days, the forms were removed, and the briquettes were allowed to air dry. Observations were made as to rate of drying and shrinkage along with appearance and apparent specific gravity.

The moisture content of the samples used in all the three series was roughly 90 per cent. The weight of the samples taken, i.e., to fill the cement form—3 briquettes to a mould—was approximately 190 grammes and occupied a volume of 190 c.c. (63 c.c. for each briquette). The time required to reach constant weight was about 12 days after the time they were taken out of the mould.

OBSERVATIONS—EFFECT OF FAST AND SLOW DRYING

The three series were dried in the laboratory where the rate of drying may be described as rapid for this size of briquette; practically all the briquettes developed cracks. As a rule, however, the extent of checking varied directly with the length of time of extra maceration, i.e., with the degree of maceration.

On a previous series of briquettes which were dried in the open air, checking within the first day or so prevented further observations being made. Here the checking varied directly with the rate of drying as well as with the degree of maceration. These observations were also substantiated when larger, field-size briquettes were air-dried.

Results	Volume shrinkage by drying	Air-dried briquette	
		Moisture content	Apparent Sp. Gr.
	Per cent	Per cent	
First Series (30 min. mixing)—			
Original sample I	81·5	12·9	0·92
5 min. extra maceration	88·9	13·7	1·03
15 " " "	89·7	9·8	1·22
30 " " "	90·3	16·4	1·18
1 hr. " "	90·7	16·9	1·27
2 hrs. " "	90·0	18·9	1·28
Second Series (5 min. mixing)—			
Original sample II	88·3	10·8	1·01
5 min. extra maceration	88·8	14·1	1·12
15 " " "	89·2	11·4	1·15
30 " " "	88·9	17·0	1·14
1 hr. " "	89·7	15·1	1·21
2 hrs. " "	90·3	15·6	1·26
Third Series (belt conveyer)—			
Original sample III	85·6	17·6	0·93
5 min. extra maceration	86·0	15·9	1·00
15 " " "	86·4	18·8	1·03
30 " " "	86·7	16·8	1·04
1 hr. " "	86·8	12·3	1·07
2 hrs. " "	88·1	11·7	1·22

INTERPRETATION OF RESULTS

(*a*) The rate of drying varied only slightly with the degree of maceration and the total time to come to a more or less constant air-dried moisture content, say 15 to 18 per cent, was practically the same and independent of the extent of mixing or maceration.

(*b*) The tendency of moulded (wet) peat to crack or check on air-drying varied directly with the degree of maceration and also with the rate of drying.

(*c*) The shrinkage in volume which took place when moulded wet peat was air-dried varied directly with the degree of maceration and since the tendency to crack or check also varied directly with the extent of maceration, it would seem that this tendency is co-related with the shrinkage qualities.

(2) Repetition of Test No. 1, using Larger Moulds and Drying in Open Air

Observations were made on air-drying of peat in wooden forms, using for the purpose samples of wet peat I, II, III and III A respectively. The dimensions of forms were roughly 6 by 3 by 2 inches, and the weight of the peat samples taken averaged 1,290 grammes. This series was dried in the open air in day time, and in the laboratory at night.

—	I	II	III	III A
Moisture content at start.............................%	90·4	89·6	88·3	88·2
Moisture content, air-dried..........................%	13·0	13·2	17·9	16·0
Apparent Sp. Gr., air-dried..............................	0·92	0·98	0·90	1·13

Here again the rate of air-drying varied only slightly and the total time to come to constant weight was approximately the same for all four samples, viz., 9 days.

Air-dried bricks from I and II showed very little checking while III and III A showed considerable checking during the third and fourth day. On the seventh day III A was badly cracked and broke easily by hand pressure along these cracks.

(3) Air-drying in Forms 8 by 5 by 4 inches

Four samples of wet peat were taken as follows:—

IV—Jeffrey macerated peat from Alfred.
IV—15 mins. extra maceration in laboratory.
IV—30 " " " "
IV—60 " " " "

The samples taken, averaging 2,815 grammes each, were dried in the open air, as described in (2) above.

IV with extra maceration for		15 mins.	30 mins.	60 mins.
Moisture content at start.............................%	88·5	88·5	88·5	87·0
Moisture content, air-dried..........................%	19·3	17·0	21·1	19·4
Moisture content after being oven-dried and standing 4 months......................................%	11·5	9·8	9·8	11·3
Apparent Sp. Gr., air-dried..............................	0·93	1·11	1·15	1·18
Shrinkage by air-drying.............................%	74·0	75·0	76·0	77·0

The rate of drying varied only slightly and the total time to come to constant weight was approximately the same for all four samples, viz., 20 days.

The condition of the air-dried bricks was not good. All were more or less cracked, and again their friability varied directly with the degree of maceration. The shrinkage percentages given above are rough figures, as due to the cracking only rough dimensions of the air-dried block were available.

INTERPRETATION OF RESULTS FROM TESTS NOS. 1, 2, AND 3

(*a*) The results of observation of the relation of the rate of drying, shrinkage, and the apparent specific gravity to the degree of maceration for these large-size moulded bricks, corresponded to those for the small cement mould briquettes, in that the apparent specific gravity, shrinkage, and tendency to check varied directly with the degree of mixing or maceration.

(*b*) The apparent specific gravity of the air-dried bricks from samples III and IV, viz., wet peat macerated by the Jeffrey hammer mill shredder, was approximately the same, viz., 0·93. The apparent specific gravity of air-dried peat was fairly constant for the different amounts of the same sample taken, and the consequent different sizes of moulded brick or briquette. The apparent specific gravity of the air-dried bricks from samples I (30 minutes mixing) and II (5 minutes mixing) was 0·92 and 1·01 respectively. These samples came from the bog at different times, and no doubt from different parts of the bog.

(*c*) The shrinkage that took place on air-drying varied according to the size of the sample moulded. For example, the shrinkage for III, viz., wet peat macerated by the Jeffrey hammer mill shredder, in the small cement moulds was 85 per cent as compared with 74 per cent in the large 8 by 5 by 4-inch mould.

(*d*) Analysis of both the apparent specific gravity range and shrinkage range reported above under C 1 and C 3 where each of the samples I, II, III, and IV was further macerated, shows that with III and IV the ranges are not so wide as with I and II. This would indicate that the maceration effected by the Jeffrey hammer mill shredder in samples III and IV was of a slightly different nature from that in I and II, resulting from simple mixing. Further observations, however, are necessary before the exact nature of this difference can be determined.

D. THE EFFECT OF WETTING AIR-DRIED PEAT

An air-dried peat briquette, made in the laboratory, and weighing 63 grammes, was immersed in water and the rate of its absorption of water noted as follows:—

Moisture content of original air-dried briquette....... 9·5 per cent
" " after over night in water...........26·0 "
" " " 6 days in water.............37·5 "
" " " 29 " " ....40·0 "
" " " 57 " " ....43·0 "

On wetting the briquette swelled only slightly, and broke easier than before. On allowing it to air-dry again the moisture content at the end of a week came back to 9·8 per cent.

These results substantiated the observations frequently made that once peat is air-dried it will neither take in water, nor swell to any great extent, and that any water that is absorbed on wetting is given up freely on re-drying.

E. COMPARISON OF APPARENT SPECIFIC GRAVITY OF AIR-DRIED MACHINE PEAT MADE AT ALFRED DURING THE SEASONS OF 1922 AND 1917 RESPECTIVELY.

—	1922 Air-dried peat	1917 Air-dried peat
Apparent specific gravity of single lump..................................	0·870	0·825
Weight per cu. ft. (in 7 cu. ft. box)......................................	32	26

APPENDIX C[1]

MANUFACTURE OF CARBONIZED PEAT AT DUMFRIES, SCOTLAND

J. O. Roos

Director of Government Testing Laboratories, Stockholm, Sweden

Martin Ekenberg, a Swedish engineer resident in London, was the inventor of a wet-carbonizing process for treatment of peat, which was tried out experimentally at a plant at Stavajo, Sweden, and which was later on closed down.

After his return from Sweden, Ekenberg, in 1907, formed in London a company known as "The International Carbonizing Company, Limited," with a nominal capital of £41,000. The amount actually paid in possibly did not exceed £500.

With the object of developing Ekenberg's inventions, a Swedish merchant, Nils Testrup of Newcastle, later formed a syndicate with a paid-up capital of £35,000. This syndicate built a small wet-carbonizing plant according to Ekenberg's designs, and continued experimental work until 1911. At that time the syndicate had expended £150,000. Ekenberg died in 1909, and was succeeded by his assistant, Olaf Soderlund.

In 1912 a new company was organized, called Wet Carbonizing Limited, with a paid-up capital of £250,000. The main shareholders of this company at present are Lord d'Albernon of the Ottoman Bank, Messrs. Arthur and Gerald Balfour, Joseph Fels, Crossleys of Manchester, and Nils Testrup. The capital has gradually increased, and was in 1919, £1,000,000, 7 per cent preferred shares and about £10,000 common, of which £900,000 has been paid up.

FACTORY AT DUMFRIES, SCOTLAND

In order to carry out Ekenberg's inventions on a commercial scale a small factory was erected in 1909, at Dumfries, on a large area of peat bog rented for the purpose. In this plant the details of the process were worked out until the mechanical difficulties had been generally overcome. At the outbreak of the war the possibility of a continuous process of manufacturing carbonized peat briquettes had been demonstrated. During the first years of the war all work was closed down, but the Ministry of War finding these briquettes to be a smokeless fuel and therefore especially suitable for use in the trenches the government took over the plant as it stood in 1917. This plant had been designed for recovery of by-products—ammonium sulphate, tars, etc.—as well as manufacture of briquettes and as the government was particularly interested in the production of peat briquettes, a new plant was erected, which was designed, in the light of experience already gained, especially with a view to manufacture of bri-

[1]Tra slat n by H. A. Leverin, Chemist, Mines Branch, Ottawa, from Teknisk Tidskrift, April 17, 1920.

quettes. The plans for this new plant were on a large industrial scale for the production of 60,000 tons of briquettes per annum. It was built at the expense of the Government during 1918 and 1919, and when completed was turned over to the company in September, 1919, under an agreement for payment within a period of ten years according to valuation. Operations were begun in February 1919, but, owing to somewhat extensive alterations, delays due to the railway strike, etc., it may be considered that an actual start in manufacturing was not made until October, 1919, when a daily production of 130 tons of briquettes was reached, equivalent to an annual output of 40,000 tons. The management of the company believe that by comparatively small changes in construction particularly in the wet-carbonizing tubes, the estimated annual production of 60,000 will be eventually reached.

THE BOG

The company is operating on a bog area consisting of two parts, Ironhirst Moss with an area of 600 acres, and Racks Moss covering 1,200 acres, situated near each other a few miles from Dumfries. The bogs are rented for a long term of years on a royalty of 3 d. per ton with a minimum annual payment of £400. They contain a fuel peat of fair quality, partly grass peat at the surface, and reed peat farther down, and are fairly free from stumps excepting at the bottom where some oak stumps occur. They are exceptionally deep, being 7 to 9 metres with an average depth of 7·5 metres, and are undrained, the water-level being from 0·3 to 0·5 of a metre from the surface. The undecomposed surface peat represents about 6 per cent of the total volume. Analysis gives content of:—

	Per cent
Ash	5·0
Sulphur	0·85
Phosphorus	0·002
Nitrogen	1·45

Calorimetric values are:—

Surface peat	4,925 calories
Bottom peat	5,255 "
Average	5,120 "

PLANT AND METHOD OF OPERATION

The factory is 1 kilometre from the edge of the bog and about 10 kilometres from Dumfries on the Glasgow-Carlisle Railway, with a spur in to the works. The object of the process is to be independent of air-drying. The method is to remove part of the water by pressure and the remainder by air-drying, thereby obtaining a peat powder with low moisture content which can be pressed into briquettes. Owing to the special war conditions it was desired to obtain as great a production of briquettes as possible, consequently coal slack was used as a fuel for carrying on the operations.

Pressing does not remove a great deal of the water from raw peat unless its colloidal properties are first destroyed. This is accomplished by the wet-carbonizing process under which the raw peat slop is heated in a system of tubes to about 200° C. under corresponding pressure. During the process the peat slop is partly carbonized, the organic structure is

partly destroyed, it loses its colloidal character and can be pressed in ordinary filter-presses to about 30 per cent dry substance, and by means of hydraulic presses to 50 per cent dry substance. The remaining water is evaporated by heat supplied by the waste gases from the power plant. The mechanical devices required for this process consist generally, of the following, as shown on accompanying diagram (Figure 46):—

Excavator: On the bog with pumping system to move the peat slop to the factory.

Peat Reservoir: For storing an amount of raw peat sufficient for two days' production.

Liming Apparatus: For adding lime to neutralize acids formed during wet-carbonizing.

Pumping Plant: For transportation of the peat slop to the wet-carbonizing tubes.

Wet-carbonizing System: For heating the peat slop to 200° C. for a sufficient length of time, and for recovery of the heat by reverse flow method.

Filter Presses: For pressing the wet-carbonized peat powder to 30 per cent dry substance.

Disintegrators: For pulverizing the pressed cakes and sifting the powder.

Drying Plant: (Rigby system) for drying the peat powder by means of waste gases from the power plant, obtaining the bulk of the dry powder in so-called cyclone chambers, and the remaining dust by scrubbing the gases.

Briquetting Plant: For pressing the dry powder into briquettes.

Power Plant: Generating electric power for all requirements.

Loading and Unloading Appliances: Including a railway spur for unloading of coal and loading of briquettes.

DETAILED DESCRIPTION OF THE PLANT

Excavator (A, B, C, D)

The excavator consists of a floating dredge, macerator, root remover, and pumps for transportation of the slop to the factory. The excavator plant was erected at the edge of the bog. It floats on a pontoon 33 metres long, 12 metres wide and about 1·8 metres deep with draught of about 1·4 metres. The pontoon is kept in place by steel ropes anchored on the shore, also by means of supports from the stern against the bottom of the bog. By manoeuvring these lines by motor control the dredge works on the arc of a circle on the edge of the bog. The excavator proper consists of an elevator with scoops holding about $\frac{1}{4}$ ton each, excavating at a speed of about 40 scoops per minute. The scoops cut the bog sideways in two layers. They are as a rule only half-filled, and raise on an average about 300 tons of wet peat per hour, corresponding to 18 tons of dry substance per hour. The excavated peat is dumped into a hopper where a root remover of special construction is installed removing average-sized roots and stumps which are thrown back into the excavation. Larger stumps and roots must be removed by hand from the buckets in motion.

In some cases it might be necessary to stop them for that purpose. From the hopper the peat mass passes through a number of macerators (five) alongside one another which are similar to the Svedala macerators although considerably larger. The macerated peat is afterwards forced by two large double-acting pressure pumps into the pipe conveyer. Seven motors were used on the excavator, viz., one for moving the pontoon, one for shifting the buckets, and one for driving them, three for the macerators, and one for the pumps, and in addition one for electric lighting. The pressure of the pumps with the present length of the pipes is about 20 atmospheres. Maximum pressure of the pumps is about 30 atmospheres. The rate of excavation is limited by the capacity of the pumps and averaged 300 tons of wet peat per hour. The power consumption for excavating and pumping amounts to about 1 kw. hr. per ton of raw peat. Four men per shift were required and the excavator was in operation only for one shift daily. From a mechanical point of view, in my opinion, the excavator is exceptionally well built, and it appears to operate with great regularity on the bog being worked.

Pipe Conveyer (E)

The system comprised two parts, one floating on the water, and the other on land. The floating portion of the pipe system consists of 3 lengths, each about 100 metres long, joined by movable couplers to one another and also to the excavator and the land pipe. These couplers are of forged steel pipe with an inside diameter of 0·46 metre and about 5·5 metres long, joined with threaded flange couplings. The system floats on small pontoons of about 0·6 of a metre diameter and about 1 metre long, one on each side, about 2 metres apart. By means of this movable floating pipe line, all the peat within the arc of a circle of 300 metres radius can be excavated without further lengthening.

The rigid pipe line on land is of forged steel tube 0·6 metre in diameter. Its present length is 1,600 metres. Alongside this rigid conduit is a light track for transportation of pipe lengths required for lengthening the pipe system. The lengthening is arranged in advance so that when the excavator has to be moved farther out on the bog, the coupling with the floating pipe system can be quickly accomplished. This is seldom required (about once in three months).

Peat Reservoir (F)

The conduit discharges into a peat reservoir adjacent to the factory, holding about two days' requirements of peat slop. It is built up with earth and gravel walls, and lined with boards. Dimensions about 75 metres long, 40 metres wide, and 5 metres deep. The peat mass is of slow-flowing consistency, and feeds into the macerators under its own pressure.

Macerators (G)

These are three in number and of the same type as those on the excavator (enlarged Svedala-type) and effect a further maceration of the peat mass.

Addition of Lime

The raw peat contains certain humous acids which during the process of wet-carbonization are changed into other acids such as formic, acetic, oxalic, and others. These acids attack the wet-carbonizing tubes, and must therefore be neutralized. This is accomplished by the addition of slaked lime in a special apparatus before the peat enters the macerators. It has been found that the most suitable amount of lime to be added is 3 to 4 per cent of the dry substance of the peat. The lime increases considerably the ash content of the peat powder, and also causes deposition of oxalate of lime in the wet-carbonizing tubes, which will be dealt with later.

Elevator and Storage Tower for Raw Peat (H)

From the macerators the peat slop is elevated into a small storage tower from which it flows to the pumping system.

Pumping System (K)

In order to pass the peat through the wet-carbonizing tubes at a certain speed, and to resist the steam pressure of 200° C., a pump pressure of about 40 atmospheres is required, which is produced by a series of motor-driven pressure pumps. Each motor drives by means of gear wheels two symmetrically lying pumps each with two pistons. Each piston feeds a wet-carbonizing tube. There are five such systems each consisting of one electric motor, two pumps of two pistons each, and four wet-carbonizing tubes. Each motor requires about 70 kw. The number of men required for the pumping plant is six for each shift. The plant is especially well designed and functions with great regularity.

Wet-Carbonizing System (L,M,N,O)

In this plant the object is to heat the peat mass to 200° C. for a period of 18 minutes, and by employment of reverse flow recover the greater part of the heat, so that the water pressed out will be of only slightly raised temperature, compared with the original mass. The temperatures mentioned below were obtained at wet-carbonizing tube No. 17, and checked by me. The plant consists of five systems each of four units. Below, one such unit is described. The raw peat is pressed through a tube of 4 inches outside diameter and $\frac{1}{4}$ to $\frac{3}{8}$ inch in thickness, and of very great length, which passes through three different stages of heating.

The Water Regenerator (L)

The inner tube is surrounded by a cast iron pipe of 13 centimetres inside diameter. In this outside tube the water pressed out from the filter presses runs by its own pressure in the opposite direction to the movement of the peat slop. The length of the water regenerator, which is arranged in coils, is about 67 metres. The present plan of conducting the filtered-out water through the tubes by its own pressure has not proved satisfactory, as only about 3 tons of water per hour passed through the tubes, whereas the total amount of water pressed out from the peat amounted to 9 tons per hour. Consequently the efficiency of heat recovery obtained was low. (Temperature of raw peat entering the system 8·2° C. and leaving the system 21·6° C. Temperature of water entering 58·9° C., and leaving 19·3° C.) The water after regeneration was allowed to run out on the bog, as well as a large amount from the filter presses, that could not pass through the tubes.

The Warm Peat Regenerator (M)

In the warm peat regenerator the inner tube containing the raw peat is led through a steel tube of 13 centimetres inside diameter. In this outside tube the warm peat slop from the reaction tower moves in the opposite direction to that of the raw peat. The length of the warm peat regenerator is 243 metres, lying horizontally in a coil of four lengths in the open air. These are surrounded by an insulating cover of slag wool and corrugated sheet metal. Temperature of raw peat entering 21·6° C. and leaving 138·9° C. Temperature of warm peat entering 197·4° C. and leaving 74·1° C.

When it was discovered that the acids formed during wet-carbonizing attacked the iron tubes, their length of life being only three to six months, it was found necessary to neutralize with lime. It was then found that lime salts at the lower temperature precipitated on the walls of the wet-carbonizing tubes. The deposit so formed consisted generally of oxalate of lime, which was rapidly formed of such thickness that the conduction of heat between the warm and cold peat slop became so poor that the calorimetric efficiency was appreciably reduced. It became necessary to scrape the inside and outside tubes every fourth day. This from the point of view of continuous operation is most unsatisfactory, as it requires 5 to 7 men per shift for that work. Experiments are being made with a view to minimizing these difficulties.

The Steam Jacket (N)

The inner tube with the preheated raw peat next is led through a steam jacket 31 metres long through which it passes in coils of four, and in some systems six, having therefore a length of 126 or 200 metres. This steam jacket is supplied with steam at 205° C. from the boilers, and raises the temperature of the peat to about 200°C. Temperature of incoming peat was 138·9°C. and outgoing 199·9°C.

Reaction Tower

In order to obtain effective carbonization at 200° C. the peat mass must be kept at that temperature for about 18 minutes. This is done by leading the heated peat into a cylindrical tower of steel plate lined inside with clinker. (Inside diameter 1·2 metres, height 4·5 metres) where the peat passes through a number of levels from below upwards being kept in motion by a central stirrer. The outgoing temperature from the tower was 197·4° C. Capacity of the tower about 10 tons per hour. At the time of my visit 9 tube units were in operation, but the plant would permit operation of 12 units (3 systems). Besides these, 8 units were in process of being cleaned. The warm wet-carbonized peat flows through the outside tube of the warm peat regenerator to the warm peat reservoir. This consists of three cylindrical tanks with a capacity corresponding to a couple of hours run, where the gases formed are taken off and from which the peat mass under pressure of 7 to 8 atmospheres passes into the filter presses. The temperature in the warm peat reservoir was 74·1°C.

Filter Press Plant

There are eleven presses each of 94 frames making press cakes 50 inches by 50 inches. In order to obtain a favourable pressing a temperature of at least 76°C. is required. The actual temperature was 74°C. Using a pressure of 100 pounds per square inch a press cake was obtained with very constant dry substance content of 30 per cent. Each pressing by one press produced about 7 tons of press cakes equal to 2·1 tons of dry substance. Each operation of the press took about $2\frac{1}{2}$ hours. The press cakes were removed by hand. The filter presses are of cast iron and of standard type, and the filter cloths of ordinary canvas. Seven men per shift were required making 60 pressings in 24 hours. The press cakes drop through a breaker (R) on a belt conveyer (S) which brings the material to a disintegrator (T) and to centrifugal mills (U) for pulverizing. The powder is conveyed for drying to a storage room with sloping bottom (V). The water extracted by the filter presses is led through pipes to the outer tube of the warm water regenerator in order to give up its heat to the incoming raw peat. Owing to unsuitable arrangements there is a considerable loss of heat in the filtering process through formation of steam by which the temperature of the water pressed out was lowered from 74°C. to 58·9°C. From a mechanical point of view the filter presses functioned satisfactorily and with regularity.

Drying of Peat Powder

The drying of the peat powder is effected by the Rigby process in the following manner. The moist powder is brought to the mouth of a large insulated boiler plate cylinder, 1·8 metre in diameter and 200 feet long, where it is caught up by the waste gases from the power plant which are forced through the tube by fans at an incoming temperature of 300°C. to 350°C. Owing to their carbonic acid content (about 10 per cent) no ignition will occur below 700°C. Owing to their speed the gases pick up the peat powder. The volume of gases and the amount of peat powder are so proportioned that at the other end of the cylinder, the temperature is about 85°C. and the moisture content of the peat powder 8 per cent. In order to separate the dry peat powder the gases are led at high speed through the so-called cyclone chamber (h) where the peat is deposited, and by a conveyer brought to a storage hopper over the large briquetting presses (c, d, e, f, and g) in which it does not remain long. The gases leaving the cyclone chamber are led through a water tower where any remaining peat dust is washed out and returned to the filter presses. The drying system, from a mechanical point of view, functioned satisfactorily and with great precision. On the other hand it was found that the loss of peat powder remaining as dust in the gases was considerable, estimated at 10 per cent.

Briquetting Plant

The installation directly follows that of the German brown coal briquetting plants, and two of the machines were of standard type from the firm Maschinenbaugesellschaft Buckau, Magdeburg. During the war a large press was built in England, so they now have three of them, two large and one smaller. These presses are driven according to the German system with steam of 5 atmospheres, and a back pressure of

about ½ atmosphere. The exhaust steam could not be utilized. The briquetting presses worked very satisfactorily, the smaller one delivering 2 tons and the large one 3 tons per hour. One press was held in reserve. During November the output was about 125 tons of briquettes daily. Labour requirement was 3 men per shift.

The Boiler Plant

This consisted of 4 Babcock and Wilcox boilers, each of about 3,400 square feet heating surface producing 15,000 pounds of steam of 300 pounds pressure per hour. They were supplied with chain grates and were fired with slack coal. Three were kept in operation and one in reserve. The waste gases were led by fans to the drying plant. As these were not sufficient for the drying of the powder with 70 per cent moisture, there was also a small furnace where coal was burned directly, the gases from which at high temperature were mixed with the gases from the boiler plant. Labour required, 6 men per shift. The boiler plant was built in one of the earlier stages and the removal of ashes and slag was awkward, requiring an unnecessary amount of labour.

The Power Plant

All power required was supplied from two steam turbines of 1,700 kw. from the firm Beliss-Morcom, Ltd., Birmingham. Steam pressure 300 pounds, condenser pressure 28 inches of water. One of the turbines was held in reserve. Energy transmitted to the larger motors was supplied by an A.C. generator, from the British Electric Company, of 3-phase current at 3,300 volts tension. For the smaller motors this was transformed down to 440 volts. The total power required with the present output of 40,000 tons per year was a maximum of 1,050 kw. divided under the following headings:—

Excavator	250 to 300 kw.
Pumps and wet-carbonizer	160 kw.
Fans for drying	240 kw.
Condenser for turbine	100 kw.
Other purposes	300 to 250 kw.

Size of Buildings

In order to give an approximate idea of the size of the plant, the approximate size of the various buildings is stated in the table below. Most of these were united to form a large complex. Materials used in most cases were steel and corrugated plate. A few of them had brick walls.

Name of building	Approx. length	Width	Height to eaves	Approx. volume
	Ft.	Ft.	Ft.	Cu. ft.
House for macerators, etc	24·6	34·4	36·0	35,314
Wet-carbonizing pump house	114·8	68·0	23·0	185,035
Heating house	114·8	19·6	39·3	98,172
Heating house	114·8	83·1	18·0	170,213
House for filter presses	98·4	41·0	37·7	179,042
House for accessories	118·08	36·0	32·8	170,213
House for pulverizing, etc	75·6	44·2	39·3	135,605
Cyclone chambers, etc	47·5	78·8	39·3	150,437
Briquetting plant	47·5	42·6	39·3	97,113
Power station, etc	66·5	46·0	39·3	106,295
Boiler house and accessories, houses	42·6	111·5	18·0	116,536
Briquette storage	68·0	36·0	36·0	92,875
Sundry small buildings	....	....	....	123,600

PRODUCT OBTAINED

Peat-coal

The original material, raw peat, has the colloidal or gelatinous property common to all fuel peats. By heating in water to a temperature about 200° C. under corresponding pressure a part decomposition of the organic substances occurs, which becomes more complete the longer it is subjected to this temperature. In this case 200° C. during 18 minutes was employed. Part carbonization takes place whereby certain organic matters are decomposed, forming water, carbonic acid, oxalic acid, acetic acid, and other compounds. The remainder is the peat powder, which during the process has lost its colloidal property and permits of removal of the greater part of the water by mechanical pressure. By wet-carbonizing the peat mass loses in weight. In this case 87 per cent of the dry substance contained in the raw peat was recovered. At the same time the calorific value of the dry substance was somewhat increased, so that the recovery by wet-carbonizing amounts to about 92 per cent according to laboratory tests. The wet-carbonized and dried peat powder is pressed into briquettes which are the final product.

The Briquettes

These were of rectangular shape and made in two sizes:—

Dimensions with the smaller press 120 by 70 by 18 mm.
Weight 2 kilograms
Dimensions with the larger press 185 by 107 by 24 mm.
Weight 6 kilograms

The briquettes are black with a shiny surface and a brown, amorphous break. To what degree they are able to stand storage in the open air, I have been unable to obtain any data. In a dry place, however, they can remain for a very long time without undergoing any appreciable change. They burn with a flame, and can be used advantageously in both open and closed fire-places. Owing to their regularity in shape and cleanness they are especially advantageous for domestic fuel. The ash depends, naturally, on the composition of the peat. In this case, owing to addition of lime, it was white in colour. The briquettes break slightly in firing and with very strong draught might tend to form sparks. Experiments are now being made on the Norwegian State Railways as to their use for locomotive fuel. As a general opinion it may be said that the briquettes appear to be a specially good fuel and easy to handle. The calorific value of the briquettes depends, naturally, on the ash content and composition of the raw peat. Analyses of wet-carbonized peat from different parts of the bog gave as an average:—

Raw peat	5,120 calories
Lime	4 per cent of the dry substance
Moisture of briquettes	About 8 per cent
Calorific value of briquettes	5,435 calories

Samples taken by me during 48 hours' trial run, and analysed at the Materials Testing Station at Stockholm gave from absolutely dry sample:—

Ash	9·8 per cent
Calorific value	5,150 calories
As delivered, ash	8·9 per cent
Moisture	9 per cent
Effective calorific value	4,380 calories

Thus, the calorific value of these briquettes was lower than the average figure given at the plant, which probably arose from the fact that at the time of my visit some part of the bog was being worked where the peat was of inferior quality. For purpose of comparison it may be stated that the best English steam coal (best South Yorkshire) as delivered gives the following average:—

Ash	5 per cent
Effective calorific value	7,000 calories

TECHNICAL HEAT-EFFICIENCY OF THE PLANT

As all power and heat required at the plant were obtained from the use of slack coal under the boilers with a view to obtaining the largest possible amount of saleable briquettes, it was of great importance to obtain knowledge of the fuel consumption as compared to the amount of briquettes manufactured. No daily operating chart seemed to be kept. On that account the Swedish Commission arranged for a trial run of 48 hours in two periods of 24 hours each. Owing to favourable local conditions the amount of fuel used and briquettes produced could easily be ascertained with sufficient accuracy in the following manner. A certain number of railway cars loaded with coal were weighed on car scales and the figures checked. The boilers were fired with the coal from these cars after which the empty cars were weighed. During the first period of the trial run, one of the larger and the smaller briquette press, and during the second period the two large presses were in operation. The length of the string of briquettes was measured, and a number of 60-foot lengths of these weighed.

—	Briquettes made	Coal used
	Tons	Tons
First 24-hr. period	132	114
Second 24-hr. period	140	128
Average per 24 hours	136	121

General samples of the coal and briquettes were taken and afterwards analysed at the Government Materials Testing Station in Stockholm. Moisture content of briquettes as per analysis at the company's laboratories was 9 per cent. Analysis at Stockholm gave about 10 per cent. It is possible, however, that some water might have been absorbed in transportation.

Results of analyses at Stockholm on samples as delivered:—

—	Briquettes	Coal
Moisture	9%	11·4%
Ash	9%	15%
Calorific value	5,150 calories	6,300 calories
Effective calorific value	4,380 "	5,300 "

From this is obtained an average number of effective calories per day:—

Briquettes made	596,000,000
Coal consumed	641,000,000

Results of this trial run show that practically as many calories were consumed as produced. This means that if instead of coal, the peat briquettes had been used as fuel for the plant, the entire output would have been consumed leaving no balance for sale. Notwithstanding this situation the plant might be kept in operation at a profit, or at least without any considerable financial loss, owing to the State regulation and control of prices for coal, which fixed a maximum price of 30s. per ton for slack coal, while the briquettes were sold free from restriction at a price of over 90s. per ton. That the directors of the company, to whom the unsatisfactory results obtained must have been known, should in spite of that invite foreign experts to inspect the plant was partly due to the fact that they considered that many complex mechanical problems had been cleverly solved, which is also my opinion, and that a plant like this for manufacturing peat briquettes according to the wet-carbonizing system must be considered a great step in advance; and partly because they felt convinced that by some improvements, and changes in details, a new plant could be built which would have a satisfactory efficiency.

PROPOSED IMPROVEMENTS TO OBTAIN SATISFACTORY EFFICIENCY

The technical staff of the company have made calculations of the possible efficiency obtainable in a new plant designed for the production of 100,000 tons of briquettes for sale annually. These I was allowed to examine. In these calculations the heat losses of the projected plant had been figured in the most important details upon the assumption in every case that the heat-saving appliances used should be of the utmost efficiency which technical skill can produce. By combining these calculated heat losses a result was obtained of 60 per cent efficiency, i.e., 60 per cent of the wet-carbonized peat could be sold as briquettes and 40 per cent would be consumed by the plant. Thus, the projected plant should have a gross production of 170,000 tons. To be able to figure out synthetically the efficiency of so complicated a plant is not in my opinion, feasible, since when put into actual practice so many unforeseen circumstances and conditions inevitably arise. The investigation has, however, in my opinion great value from the point of view that 60 per cent is the utmost limit of heat-efficiency which can be obtained from an ideally-built plant according to the wet-carbonizing system, and that the limit of practical efficiency must lie considerably below that point. From a study of the existing plant a number of details can be picked out where considerable improvements are necessary and even possible to produce increased efficiency. The most important of these are the following:—

Steam Plant and Power Station

By burning wet-carbonized peat and dry peat powder under the boilers a much improved thermic efficiency can be obtained than under the present system of firing slack coal on grates. By replacing the present steam turbines which were not carrying a suitable load by the more economical Ljungstrom steam turbine better results should be obtained.

Wet-carbonizing System

A specially vital part of the plant from a heat efficiency point of view is the wet-carbonizing system where the heat is reclaimed in the warm water regenerator and the warm peat regenerator by reverse flow method. These as mentioned did not work satisfactorily. From the point of view of reclaiming heat as well as keeping them in continuous operation it is necessary that some arrangement should be devised to prevent deposition of salts in the tubes, which hinder the transmission of heat and cause difficulties in cleaning. At the same time the danger of acids attacking the tubes must be provided against. In order to obtain a better heat recovery it is proposed to lengthen the wet-carbonizing tubes from 800 feet to 1,480 feet, also the outgoing warm water must have a better circulation in the tubes of the warm water regenerator. By these changes a considerable saving of heat is possible.

Pressing Out of Water

This is probably the most important detail in the whole process. The whole idea of the wet-carbonizing process is so closely related to removing the water by pressure, that in order to prove effective, it should be possible to remove most of the water by mechanical pressure. In the existing plant the water could be reduced only to 70 per cent. The remainder of the water, i.e., 2·2 tons of water per ton of dry substance had to be removed by direct heating. An indispensable condition is that the water should be reduced to 50 per cent in the press cakes, so that only 0·9 ton of water per ton of dry substance need be removed by heat.

Experiments so far made with the object of constructing a continuous pressing system have failed, and it was considered that it would be better to press the pulverized cakes from the filter presses to 50 per cent moisture content in hydraulic presses using labour-saving machinery. By experiments this was found to be possible. Cakes weighing 5·5 kilograms were subjected to a maximum pressure of 120 kilograms per square centimetre. At each pressing 12 cakes were obtained in 25 minutes. Details for construction of such plant have not been worked out but it is evident that the plant will be very expensive, and will require a considerable amount of hand labour. It must also be borne in mind that the water pressed out from the filter presses, and which has to give off its heat to the incoming raw peat, lost 20° C. by open evaporation. This loss could be considerably lessened by suitable arrangements.

Drying of Peat Powder

In the final drying, according to Rigby's method, by the waste gases from the power plant and the collection of the powder in the cyclone chambers there is considerable loss of dust, estimated at 10 per cent. This loss could also be considerably lessened.

Briquette Presses

The present presses are constructed for brown coal plants where the exhaust steam is used for drying of the brown coal. By using better steam-saving machinery, for instance the Uniflow Engines according to the Sulzer system, it was figured that the briquetting could be accomplished with use of less steam.

Possible Results of Heat Saving

By more suitable arrangements in other parts of the plant, it is believed that still more heat could be saved. The chief engineer of the company figured that by such changes the present plant could reach an efficiency of over 50 per cent. Whether this is practical in a plant where so many details contribute to the loss of heat, I consider most uncertain. An efficiency of at least 50 per cent is necessary in order that one could even imagine the possibility of such an expensive plant becoming a paying proposition.

It is evident that such changes as mentioned will involve a great deal of new construction and experimental work at heavy cost. This work ought to be done at the present plant at Dumfries, where they have the advantage of experience and their own patents. I must emphatically warn against any such experiments on a large scale at a new plant in Sweden. Such an enterprise without the resources which from a technical and mechanical point of view are obtainable in England would take too long a time and would require enormous expenditures of money which assuredly would be very difficult to recover.

POSSIBILITIES OF APPLICATION OF THE DUMFRIES METHOD IN SWEDEN

As a basis for even thinking of applying the Dumfries method it must be assumed that it will have an efficiency of at least 50 per cent. The following discussion, therefore, proceeds on the assumption of the improvements at the Dumfries plant being made, and its efficiency thereby raised from nothing to 50 per cent.

Cost and Size of Plant

As already mentioned considerable costly new construction is required and the units are very large. As a consequence the cost of the plant is very high in proportion to its production, and, as is generally the case in such complicated plants, the cost per ton of briquettes is higher for a small plant than for a large one. If we assume a gross production of 80,000 tons with the above efficiency of 50 per cent, this would yield 40,000 tons of saleable product per year. It is impossible to give with any degree of accuracy the cost of such a plant, partly because of new expensive equipment required, such as the proposed hydraulic presses for reducing the water content from 70 per cent to 50 per cent, and any estimate of cost must be largely guesswork. Estimating on figures obtained from the company, based on pre-war prices, a plant to give 80,000 (i.e. 40,000 net) tons production annually would cost in Sweden 12 to 15 million kronor, inclusive of bog, railway spur, and workingmen's cottages. Assuming that cost of plant and working capital amount to 14 million kronor, this would represent a capital cost of 350 kronor per ton per year of saleable briquettes. For a smaller plant this cost will be higher, and for a larger plant somewhat lower. If we assume that the bog has an average depth of 3 metres with 92 per cent water content an area of 70 acres would be excavated per year, and for a

20-year period 1,400 acres. It is apparent that only a very small number of bogs in Sweden would be suitable for such large production. It may also be pointed out that a considerable saving of labour is effected by the large floating excavator and the large pumping plants conveying the peat to the factory, and that the bog should be free from stumps and in such state that such an excavator can be used. Whether the wet-carbonizing system can be used for less well-humified peat, I am unable to give an opinion.

Winter Operation

It does not seem likely that the excavator can operate after the bog is frozen. Arrangements may be considered whereby excavation and conveying of the raw peat can be accomplished even during the winter, but until such problems have been solved, we must accept the fact that in Småland, for instance, continuous run for more than nine months is out of the question, which means reduction of output of saleable briquettes from 40,000 to 30,000 tons per year, and increase of capital cost to 470 kronors per ton per year.

Number of Men Employed

At such a plant the number of men employed is estimated to be about 200, divided into three shifts. The actual number at Dumfries was 250, but a number of men were engaged in experimental work. Under Swedish conditions with 48 working hours per week the number of men required would be about 230. Account must also be taken of the fact than an 80,000-ton plant would require more men than the present 40,000-ton plant, and of the additional men needed to work the hydraulic presses. So that at the lowest estimate 230 to 250 men would be required for a plant of 80,000 (40,000 saleable) tons capacity. Based on 12 months' or 360 days' operation this means a production of less than half a ton of briquettes per man employed for an 8-hour day. Cost of labour must therefore be put at least at 20 kronor per ton of briquettes.

Cost of Production

	Kronor
Maintenance and repairs, at least 3 per cent	420,000
2,000 tons lime at 50 kr. per ton	100,000
Filter cloths estimated	200,000
Other materials and miscellaneous	250,000
Administration and general expenses	250,000
Total	1,220,000

or about 30 kronor per ton of saleable briquettes. Assuming that plant cost and working capital are amortized, and amortization together with interest amounts to 14 per cent per year, this will amount to 50 kronor per ton, thus making cost of production, according to my calculation,—

Amortization and interest, about	50	kronor
Labour cost	20	"
Other costs	30	"
	100	" per ton

The cost per ton of saleable briquettes is 100 kronor assuming 50 per cent efficiency of the plant in a continuous run for one year. With briquettes of 4,500 effective calories per kilogram, this cost corresponds to a price of 155 kronor per ton for best English steam coal of 7,000 effective calories per kilogram. From this it is evident that the Dumfries method, even provided such improvements are made to obtain above-mentioned efficiency of 50 per cent, and with a continuous run of 12 months could not be economically employed when the price of coal of 7,000 effective calories per kilogram drops below 150 kronor per ton.

The above calculations are made on the assumption that the details of the process are solved, tested out and practically applied. As this however is not the case, it is my opinion that the Dumfries method should not be attempted in Sweden. Only after it has been established that the Dumfries plant, after the above-mentioned improvements, using their own fuel, can be kept in continuous operation with an efficiency of at least 50 per cent, will it be worth investigation. Then the plant should be reported on by a commission of experts on peat technique, and mechanical and heat engineering, and calculations made as to cost and operating expenses of such a plant in Sweden.

Conclusions

The English company, "Wet-Carbonizing Ltd.," has for a period of several years carried on experiments on a large scale at Dumfries, Scotland, and built a large plant for manufacture of carbonized peat briquettes according to the wet-carbonizing method, which plant may be considered to have been in industrial operation since the beginning of October 1919.

This was designed for a yearly production of about 60,000 tons, but not fully completed in all details; the production during the trial run at the time of my visit amounted to 130 tons of briquettes per 24-hour day, or 40,000 tons per annum.

A number of details especially the excavator, pumping system, and other mechanical arrangements were designed with great skill and appeared to function with great efficiency and regularity; while other details, e.g., the wet-carbonizing system proper, the presses, etc., did not work with satisfactory efficiency.

The finished product was obtained in the form of hard, regularly shaped briquettes of 8 per cent moisture content. These were of very good quality, and should prove an efficient fuel as a substitute for coal. One ton of briquettes equals in effective heat value 0·65 ton best English steam coal of 7,000 effective calories per kilogram.

Power and heat required for the plant were obtained from use of Scotch slack coal. The heat efficiency was especially unsatisfactory, as many calories being consumed in the coal as were produced in the briquettes. The company's technical staff were, however, working on improvements on different parts of the plant by which they considered that they would be able to reach an efficiency of at least 50 per cent. This means that if carbonized peat were used for operating the plant, one-half of the peat substance could be sold as briquettes.

The cost of such improved plant cannot be given with any degree of accuracy. A plant in Sweden with 50 per cent efficiency and producing 40,000 tons of saleable briquettes in 12 months may be estimated to require a capital of 12 to 15 million kronor ($3,240,000 to $4,050,000).

Under the climatic conditions prevailing in Sweden excavation of peat could hardly be continued for longer than 9 months.

Cost of production including amortization and interest for a factory to produce 40,000 tons of saleable briquettes, assuming a 50 per cent efficiency and 12 months' continuous run, will not be less than 100 kronor per ton, corresponding to 155 kronor per ton for best English steam coal with 7,000 effective calories per kilogram.

At the present time this process should not be attempted in Sweden. Only after the plant at Dumfries has been improved, and can use its own peat fuel with a 50 per cent efficiency, should the matter be taken up and further investigated.

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BIBLIOGRAPHY

Acton, Wm.: "A Treatise on the Origin, Qualities and Cultivation of Moss Earth", 1811.

Adams, J. G.: Canada's Peat Industry, Journal of Commerce, 1913. Reprint, Journal Canadian Peat Society, December, 1913.

Alway, F.: Agricultural Value and Reclamation of Minnesota Peat Soils. University of Minnesota, Agricultural Experimental Station, Bulletin 188, 1920.

Report of Golden Valley Peat Experimental Fields, 1918 and 1919, University of Minnesota Agricultural Experimental Station, Bulletin 194.

Anderson, Jas.: A Practical Treatise on Peat Moss, 1794.

Anrep, A. (and Nystrom, Erik): Investigation of the Peat Bogs and Peat Industry of Canada during the season 1908-9, Department of Mines, Mines Branch Bulletin No. 2, second edition, 1909.

Investigation of the Peat Bogs and Peat Industry of Canada during the season 1909-10, Bulletin No. 4, second edition, 1910.

Investigation of the Peat Bogs and Peat Industry of Canada during the season 1910-11, Bulletin No. 8.

Investigation of the Peat Bogs and Peat Industry of Canada during the season 1911-12, Bulletin No. 9.

Investigation of the Peat Bogs and Peat Industry of Canada during the season 1913-14, Bulletin No. 11.

Peat Investigations, New Brunswick, Dept. of Mines, Geological Survey Summary Report, Part F, 1918.

Investigation of Certain Peat Bogs in Ontario and Quebec, Dept. of Mines, Geological Survey Summary Report, Part E, 1919.

Investigation of Peat Bogs in Ontario and Quebec, Dept. of Mines, Geol. Survey Summary Report, Part D, 1920.

Investigation of Peat Bogs in Ontario, Dept. of Mines, Geol. Survey Summary Report, Part D, 1921.

Synopsis of Information Concerning the Peat Situation in Canada, Dept. of Mines, Geol. Survey Summary Report, Part D, 1921.

Evidence before Special Committee of the House of Commons respecting future fuel supply of Canada, 1921.

Barron, E. B.: Report on the Basin of Moose River. Legis. Assembly, Ontario.

Bartel, F.: Torfkraft, 1913.

Bastin, E. S. and C. A. Davis: Peat Deposits of Maine, U.S. Geological Survey, Bulletin 376, 1909.

Beach, A.: Peat Fuel, Proc. Inst. Civ. Eng. 1900-01.

Bell, J. M.: Report on Moose River Basin. Ontario Bureau of Mines Report, 1904.

Beyer, S. W.: Peat Deposits in Iowa, Iowa Geol. Survey, Vol. 19.

Björling, P. R. (and Gissing, F. T.): Peat, its Use and Manufacture. Chas. Griffin & Company, London, 1907.

Blizard, John: The Value of Peat Fuel for the Generation of Steam. Dept. of Mines, Mines Branch Bulletin No. 17, 1917. (Publ. 447).

Results of Forty-one Tests Conducted at the Fuel Testing Station, Ottawa. Mines Branch Bulletin No. 27, 1920.

Bottomley, W. B.: The Bacterial Treatment of Peat. Reprint from Journal of the Royal Society of Arts. Journal Canadian Peat Society, July 1914.

Briggs, T. R.: Electrical Endosmose. The Journal of Physical Chemistry. Vol. XXI. 1917.

British Fuel Research Board: The Winning, Preparation and Use of Peat in Ireland. London, 1921.

The Carbonization of Peat in Vertical Gas Retorts. Technical Paper No. 4, 1921.

Report of the Fuel Research Board for the Years 1922-1923. First section.

Canadian Process of Briquetting Peat. Legisl. Assembly, Ontario, Bulletin 5, 1903.

Carbonization of Peat in Vertical Gas Retorts, Technical Paper No. 4—British Fuel Research Board, 1921.

Carter, W. E. H.: Peat Fuel: its Manufacture and Uses. Ontario Bureau of Mines Report, Vol. XII, 1903.

Chalmers, R., LL.D.: Bulletin on Peat. Geol. Survey, Mineral Resources of Canada, 1904.

Chicanot, E. L.: Canada Hopes Peat Will Replace Much Anthracite. Coal Age. Vol. XXIII, February 1, 1923.

Coville, F. V.: Blueberries on Peat Soils. U.S. Dept. of Agriculture, Bulletin 334, 1916. Directions for blueberry culture, abstract in Jour. Can. Peat Society, September, 1916.

Dachnowski, A.: The Peat Deposits of Ohio. Geol. Survey of Ohio, Bulletin 16. 1912.

Davis, C. A.: The Uses of Peat for Fuel and Other Purposes. U.S. Bureau of Mines, Bulletin 16, 1911.

The Preparation and Uses of Peat as Fuel in Alaska. U.S. Geol. Survey Bulletin 442, pp. 101-132.

Peat, its origin, uses and distribution in Michigan. Report of the State Board of Geological Survey of Michigan, 1906.

Peat Resources of the United States, exclusive of Alaska. U.S. Geol. Survey Bulletin 394, pp. 62-69.

(and Bastin, E. S.): Peat Deposits of Maine. U.S. Geol. Survey Bulletin 376, 1909.

Eecke, Ch. Van.: Exploitation Industrielle de la Tourbe. Dunod, Paris, 1918.

Ekenberg, M., Ph.D.: Fuel from Peat. Journal Iron and Steel Institute, London, No. 1, 1909.

Ekelund, Lieut.: A Solution of the Peat Problem (translation). Dept of Mines, Mines Branch Bulletin 4, 1910.

Elliott, F. C.: Results of Run-off Experiments with Muck Soils, Florida Engineering Society, Year Book 1921.

Ellis, N. W.: Peat Industry of Canada. Ontario Bureau of Mines Report, 1893.

Ells, R. W.: Peat Industry in Canada. Ontario Bureau of Mines, Report, Vol. 2, 1892.

Notes on the Mineral Fuel Supply of Canada, Proc. Royal Society of Canada, 1907.

Farlam, G. B.: Peat Land Reclamation in Germany, Journal Board of Agriculture, Vol. 26, p. 691-699. Reprinted in Journal American Peat Society, Vol. XIII, 1920.

Fleischer, M.: Die Anlage und die Bewirtschaftung, von Moorwiesen und Moorweiden, 1913.

Früh, J., and Schroeter, C.: Die Moore der Schweiz, mit Berucksichtigung der gesamten Moorfrage Beitr. Geol. Schweiz, Geotech, Ser. 3, Bern. 1904.

Geze, M.: Rapport sur l'exploitation des marais. Paris, 1910.

Gibson, Jno. H.: Peat Fuel in Russia. Paper before Mechanical Engineering Section Polytechnique Society, Moscow, abstract, Journal Can. Peat Society, April, 1915.

Gibson, T. W.: Moss Litter. Ontario Bureau of Mines Report, 1892.

Peat Fuel. Ontario Bureau of Mines Report, 1904.

Peat, Its Use and Value for Fuel, Ontario Bureau of Mines Report, 1891.

Peat as a Fuel, Peat in Europe To-day; Ontario Bureau of Mines Report, 1892.

Gissing, F. T.: Commercial Peat, its Uses and Possibilities. Chas. Griffin & Co., London, 1909.

Peat Industry Reference Book. J. B. Lippincott, Philadelphia, 1920.

(and Björling P. R.): Peat, Its Use and Manufacture. Charles Griffin & Co., London, 1907.

Gram, Dr. J. (and H. P. Lysaker) Torvbrikettering—Meddelelser fra Det Norske Myrselskap, March, 1923.

Haanel, B. F.: The Utilization of Peat Fuel for the Production of Power, Dept. of Mines, Mines Branch, No. 154, 1912.

Peat, Lignite and Coal; their value as fuels for the production of gas and power in the by-product recovery producer, Dept. of Mines, Mines Branch, No. 299, 1914.

Fuel Resources of Canada. Pulp and Paper Magazine, Vol. xvi, p. 225, 1918. Reprint Journal American Peat Society, Vol. xi, No. 3.

The Manufacture and Utilization of Peat Fuel. Trans. Am. Inst. Chem. Eng., Vol. xiii, Pt. 1, 1920. Reprint, Journal American Peat Society, April, 1921.

The Production and Utilization of Peat for Power Purposes. Eighth International Congress of Applied Chemistry, Vol. x, p. 159. Reprint Dept. of Mines, Mines Branch.

Peat Resources of the Central Provinces and Their Utilization for Fuel Purposes. Trans. Can. Inst. Mining and Metallurgy, Vol. xxvi, 1923.

Evidence before Special Senate Committee on the Fuel Supply of Canada, March 16, April 18, 1923.

Evidence before Select Standing Committee of House of Commons on Mines and Minerals. May 18, June 14, 1923.

The Fuel Situation in Canada, Trans. Can. Inst. of Mining and Metallurgy, Vol. 26, 1923.

Haanel, Dr. Eugene: Exploitation of Our Peat Bogs for the Production of Fuel for Domestic Purposes. Presidential address before American Peat Society. Trans. Am. Peat Society, 4th Annual Meeting, 1910.

The Possibilities of Canadian Peat. Address before the Toronto Canadian Club. Bulletin Canadian Peat Society, 1911.

Peat as a Source of Fuel. Commission of Conservation, 9th Annual Report, 1918. Reprint, Dept. of Mines, Mines Branch.

Harper, R. M.: Preliminary Report on the Peat Deposits of Florida, Florida State Geol. Survey. Third Ann. Rep.

Harrington, B., J.: Catalogue of Minerals, Rocks and Fossils of Canada for Paris Exposition 1878.

Hausding, A.: A Handbook on the Winning and Utilization of Peat. Translated from third German edition by Hugh Ryan, D.Sc., Professor of Chemistry, University College, Dublin. British Fuel Research Board, 1921.

Henderson, Archibald: Agricultural Resources of Abitibi, Ont. Bureau of Mines Report, 1905.

Hinchley, Prof. J. W.: The De-watering of Peat by Pressure. Jour. Soc. Chem. Ind., Vol. XLI, No. 24, December 30, 1922.

Hjetstedt, H.: Om Bränntorf—1917.

Hoering, Prof. Dr. Paul: Moornutzung und Torfverwertung mit besonderer Berucksichtigung der Trockendestillation, Berlin, 1915.

Huels, F. W.: The Peat Resources of Wisconsin. Wisconsin Geological and Natural History Survey, Bulletin XLV, 1915.

Hunt, Dr. T. Sterry: Peat and its Uses. Geology of Canada, 1884. Peat and its Applications. Geology of Canada, 1866.

Hydraulic Excavation of Peat. Can. Engineer, Vol. XLIV, No. 12, March 20, 1923.

Jack, E.: Moss Litter. Ontario Bureau of Mines Report, 1903.

Joint Peat Committee: First Report—Ontario Bureau of Mines Report, 1919, Pt. I, pp. 187-192.

Second Report—Ontario Bureau of Mines Report, 1920, Pt. I, pp. 142-156.

Third Report—Ontario Bureau of Mines Report, 1921, Pt. I, pp. 167-170.

Fourth Report—Ontario Bureau of Mines Report, 1922, Pt. IV.

Preliminary Report (Fourth Report), Dept. of Mines, Mines Branch Investigations in 1921, Fuels and Fuel Testing, No. 590.

Interim Report—Ontario Bureau of Mines Report, 1922, Pt. IV, Appendix.

Johnson, S. W.: Peat and Its Uses, New York, 1866.

Keppeler, Prof. Dr. G. Die Methoden zur künstlichen Entwässerung von Rohtorf Brenstoff-Chemie Nos. 15-16-17 Bd 3, 1922.

Kerr, W. A.: Peat and Its Products, Glasgow, 1905.

Knox, G. D.: The Spirit of the Soil. Constable & Co., London.

Larson, Alfred: The Ekenberg Wet-carbonizing Process. Transl. from Teknisk Tidskrift, December 26, 1908, Department of Mines, Mines Branch Bulletin 4, 1909-10.

(and Wallgren Ernst): Peat Industry in Europe. Report of Swedish Government Commission, 1902.

Leavitt, T. H.: Facts about Peat, Boston, 1904.

Leucauchez, A.: Traité sommaire concernant la tourbe, Paris.

Logan, Sir W. E.: Peat Distillation, Peat Occurrences in Canada. Geology of Canada, 1863.

Lysaker, H. P. (and Dr. J. Gram): Torvbrikettering. Meddelelser fra det Norske Myrselskap, March, 1923.

Macfarlane, T.: Fertilizers as Sold. Inland Revenue Dept. Laboratory, Bulletin 49, 1897.
Moss Manure. Inland Revenue Dept. Lab., Bulletin 97, 1904.
On the Loss of Substances Useful as Plant Food in Moss Manure. Proc. Royal Society of Canada, 1904.

MacMillan, J. G.: Explorations in Abitibi. Ont. Bureau of Mines Report, 1905.
Modern Methods of Utilization of Peat. The new plant at Codigoro, Italy. Transl. fr. Il Monitore Tecnico. Jour. Can. Peat Society, April, 1915.

Montgolfier, P. de: La tourbe et son utilization. Dunod, Paris, 1918.

Moore, E. V.: Some notes on the Development of the Peat Fuel Industry and its Possibilities. Trans. Can. Soc. of Civil Engineers, Vol. xxii, Pt. I, 1908.

Müntz and Lainé: Notes on Production of Nitrates from Peat. Translation Dept. of Mines, Mines Branch, Summary Report, 1907-8.

Nystrom, E.: Peat and Lignite; their Manufacture and Uses in Europe. Dept. of Mines, Mines Branch, 1908.
(and Anrep, A.): Investigation of the Peat Bogs and Peat Industry of Canada during the season 1908-9. Dept. of Mines, Mines Branch, Bulletin No. 1, 1909.

Odén, Sven: Några Kolloidkemiska torvproblem, Teknisk Tidskrift. Vol. 50.
Redogörelse för Undersökningar över Torvens Kemi, 1921.
Från en Torvvetenskaplig och Torvteknisk Studieresa, 1922.

Osbon, C. C. (and E. L. Soper): The Occurrence and Uses of Peat in the United States. U.S. Geol. Survey Bulletin 728, 1922.

Parks, W. A.: The Nipissing-Algoma Boundary. Ontario Bureau of Mines Report, 1899.

Parmalee, C. W. and MacCourt, W. E.: Peat Deposits of Northern New Jersey, Annual Report of State Geologist, 1905.

Parsons, A. L.: Peat, Its Formation, Uses, and Occurrence in New York, N.Y. State Museum, Fifty-seventh Ann. Report, 1904.

Philipp, Herbert: Peat and the Production of Power. Electro-Chem. and Metall. Industry, March, 1909.

Production of Wheat in Canada: Annual Reports of the Mineral Production of Canada, 1907-1922.

Purcell, Prof. Pierce: The Peat Resources of Ireland. Lecture given before the Royal Dublin Society, British Fuel Research Board, Special Report No. 2, 1920. Reprint, Journal American Peat Society, October, 1920.

Ries, H.: Uses of Peat and Its Occurrence in New York. Twenty-first Annual Report of State Geologist, 1903.

Roos, J. O.: Torfkoltillverkningen vid Dumfries, Skottland, November, 1919. Teknisk Tidskrift, April 17, 1920.

Ryan, Prof. H.: Report upon the Irish Peat Industries, Pt. I. Trans. Royal Dublin Society, July 6, 1908.

Sahlstrom, C. A.: Peat Coal and the Commercial By-products of Peat.

Sankey, Lt.-Gen. Sir R. H.: Utilization of the Peat Bogs of Ireland for the Generation and Distribution of Electrical Energy. (Paper read at Industrial Conference, Cork Exhibition, 1902.)

Sankey, Capt. H. R.: The Utilization of Peat for Making Gas or Charcoal. (Paper read before the British Association, Dublin, 1908).

Savage, T. E.: Preliminary Report on the Peat Resources of Iowa, Iowa Geological Survey Bulletin No. 2, 1905.

Schreiber, Hans: Neues über Moorkultur und Torfverwerting 1901-1903.

Shaler, N. S.: Origin, Distribution and Commercial Value of Peat Deposits, U.S. Geol. Survey, Sixteenth Annual Report, 1895.
Peat and Swamp Soils, U.S. Geol. Survey, Twelfth Annual Report, 1891.

Shear, Dr. C. L.: Utilization of Peat Land for Cranberry Culture. (U.S. Dept. of Agric.) Reprint Jour. Can. Peat Society, April, 1915.

Soper, E. K. (and C. C. Osbon): The Occurrence and Uses of Peat in the United States. U.S. Geol. Survey Bulletin 728, 1922.

Soper, E. K.: The Peat Deposits of Minnesota, Minnesota Geol. Survey, Bulletin No. 16.

Stansfield, Edgar, and J. H. H. Nicolls: Analyses of Canadian Fuels, Mines Branch Bulletins Nos. 22, 23, and 24.

Stillman, A. E.: Briquetting. The Chemical Publishing Co., Easton, Pa. 1923.

Taylor, A. E.: Peat deposits of Northern Indiana. Annual Report Geol. and Nat. Res. Ind. 1906.

Taylor, H. S.: Fuel Production and Utilization. Bailliere, Tindal and Cox, London, 1920.

Thaulow, J. G.: Torvbrikettering. Meddelelser fra det Norske Myrselskap, November, 1922, March 1923.

Todd, W. F.: Peat Moss, Some of its Uses, its Manufacture, its Future on this Continent. Jour. Can. Peat Society, December, 1913.

Tyrrel, J. B.: Hudson Bay Exploring Expedition, 1912. Ontario Bureau of Mines Report, 1913.

Von Seelhorst C.: Acker-und Wiesenbau auf Moorboden, 1892.

Wallgren Ernst (and Alf. Larson): The Ekenberg Wet-carbonizing Process. Trans. fr. Teknisk Tidskrift. Dept. of Mines, Mines Branch, Bulletin 4, 1909-10.

Witte, Hernfrid, Ph.D.: The Peat Bogs of Sweden and the Swedish Peat Society—A short Review. Jönköping, 1923.

Periodical Publications exclusively Devoted to Peat

Journal of the American Peat Society, United States

Journal of the Canadian Peat Society (discontinued September, 1916).

Zeitschrift fur Moorkultur und Torfverwertung, Austria.

Mosebladet, Denmark.

Hedeselskabets Tidskrift, Denmark.

Finska Mosskultur foreuingens arsbok, Finland.

Mitteilungen des Vereins fur Forderung der Moorkultur in deutschen Reiche, Germany.

Meddelelser fra det Norske Myrselskap, Norway.

Svenska torf industriens Tidskrift, Sweden.

Torf-wirtschaft, Bavaria.

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